EV Charging Infrastructure Usage in Large-scale Charging Infrastructure Demonstrations: Public Charging Station Case Studies for ARB

John Smart

Idaho National Laboratory

Plug-in Electric Vehicle Infrastructure Information Gathering Meeting

July 15, 2014

www.inl.gov

Idaho National Laboratory

Idaho National Laboratory

- U.S. Department of Energy (DOE) federal laboratory
- 890 square mile site with 4,000 staff
- Support DOE's strategic goal
  - Increase U.S. energy security and reduce the nation's dependence on foreign oil
- Multi-program DOE laboratory
  - Nuclear Energy
  - Fossil, Biomass, Wind, Geothermal and Hydropower Energy
  - Advanced Vehicles and Battery Testing
  - Homeland Security and Cyber Security

INL is a primary partner in two national electric vehicle (EV) charging infrastructure demonstrations

The EV Project

- Purpose is to build mature EV charging infrastructure in 17 US regions and study:
- Infrastructure deployment process
- Customer driving and charging behavior
- Impact on electric grid
- 12,000+ AC level 2 charging units, 100+ DC fast chargers
- 8,000+ Electric drive vehicles
- INL data collection Jan 2011 – Dec 2013
- Project partners:

blink NISSAN GM OnStar CAR 2GO

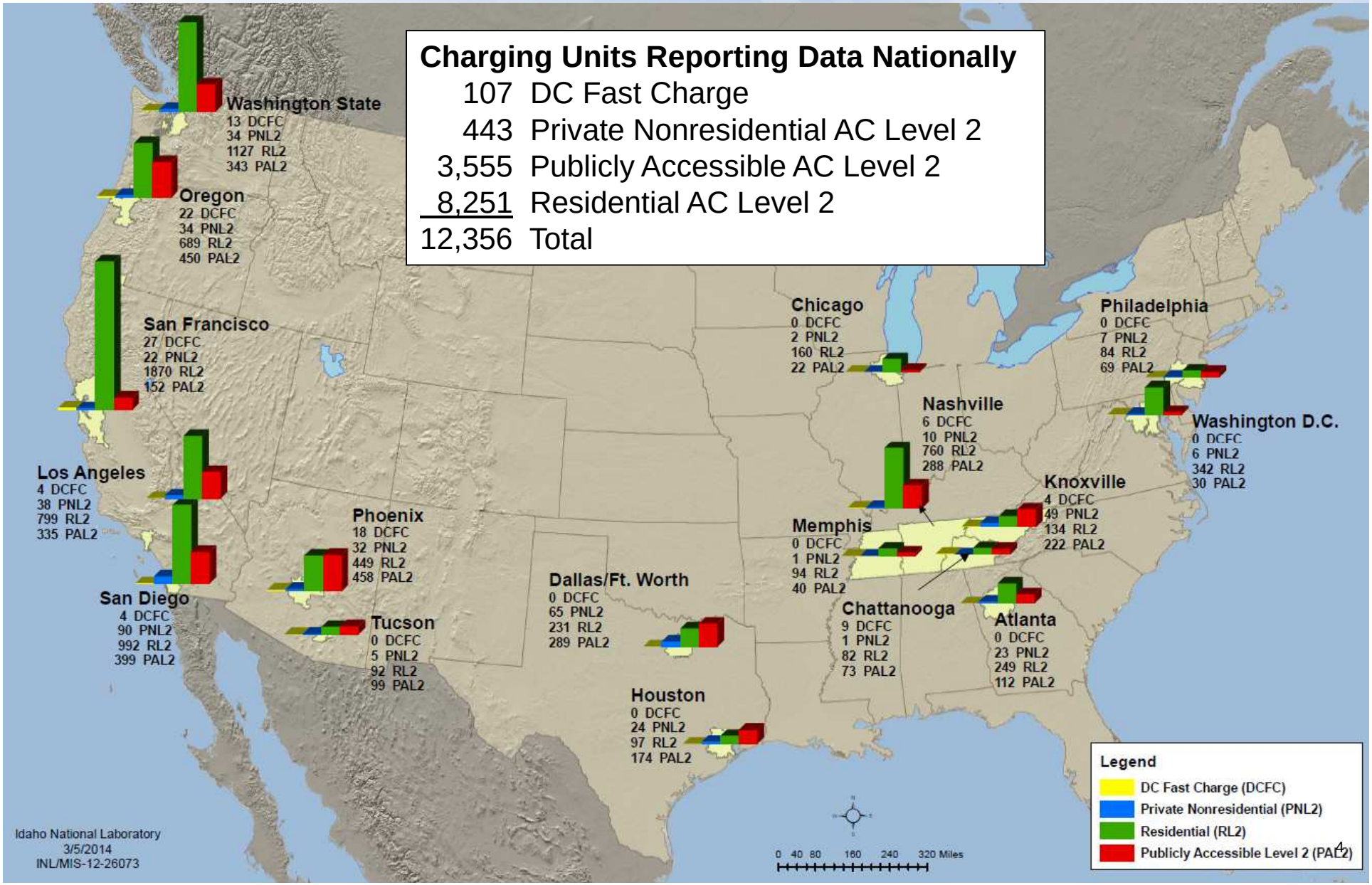
ChargePoint America

- Deploy 4,700+ residential and public AC level 2 charging units in 11 US regions
- Study customer usage of residential and public infrastructure
- INL data collection May 2011 – Dec 2013

chargepoint

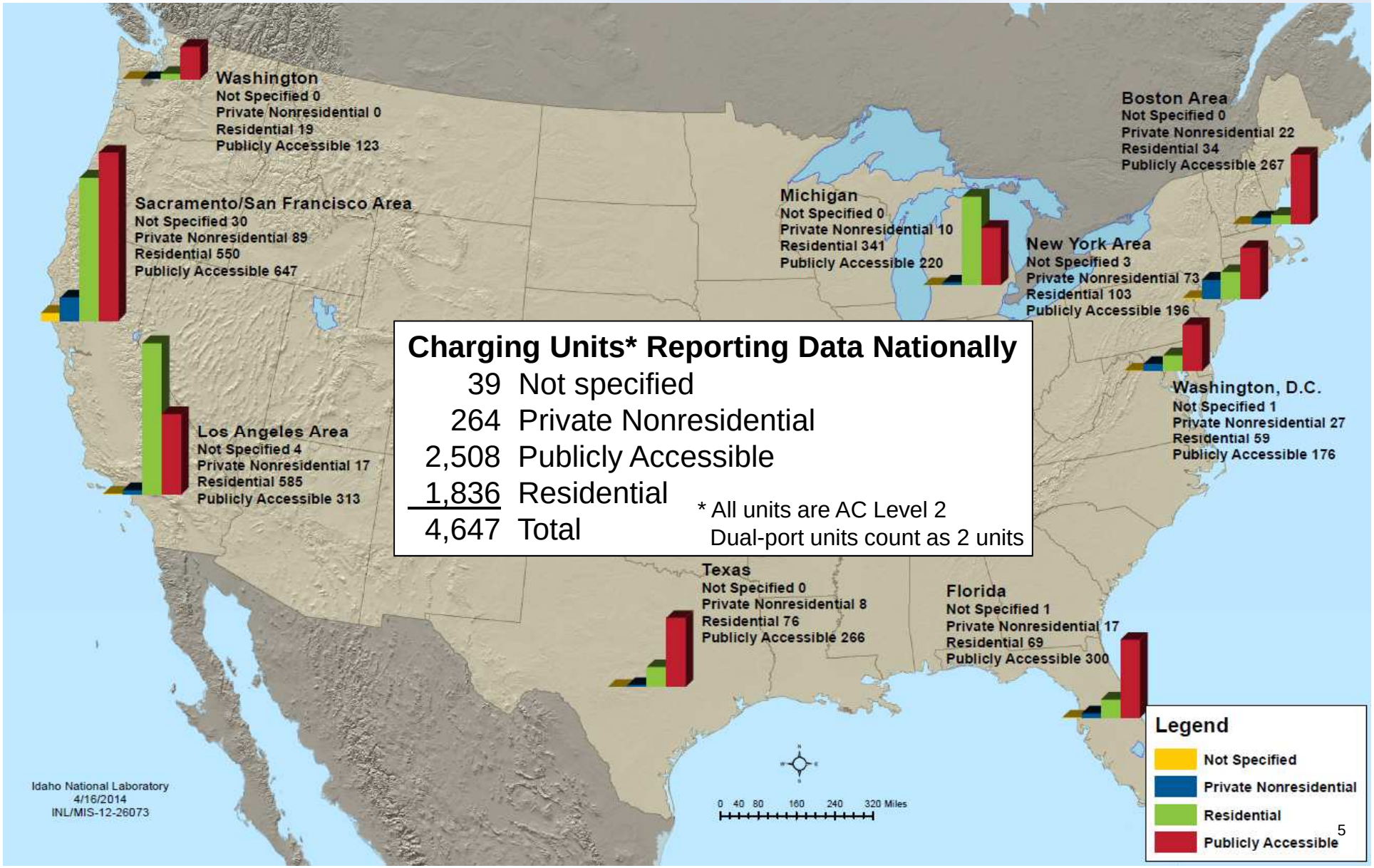
Infrastructure Deployment in The EV Project through December 2013

Idaho National Laboratory



Infrastructure Deployment in ChargePoint America through December 2013

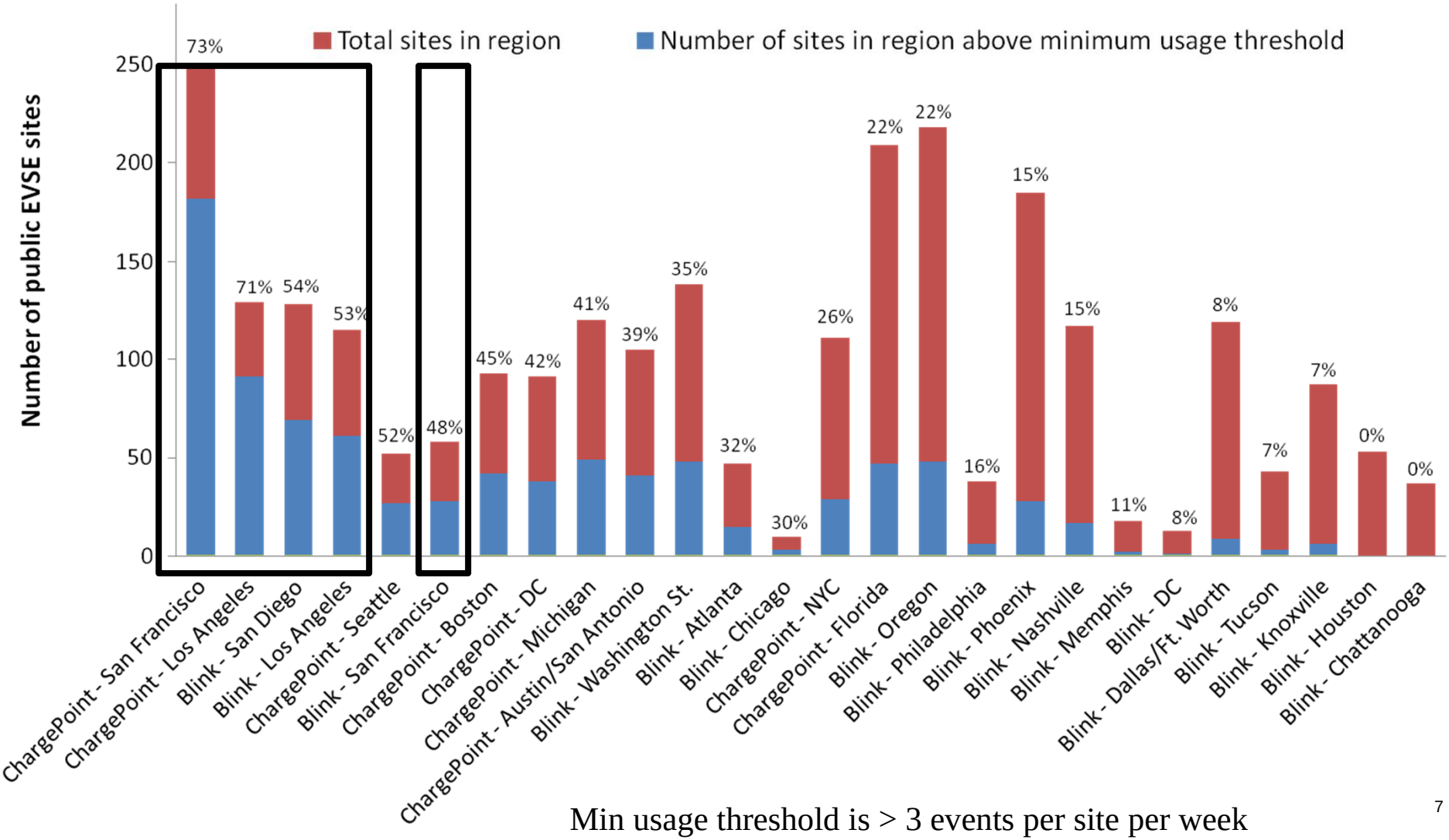
Idaho National Laboratory



Outline

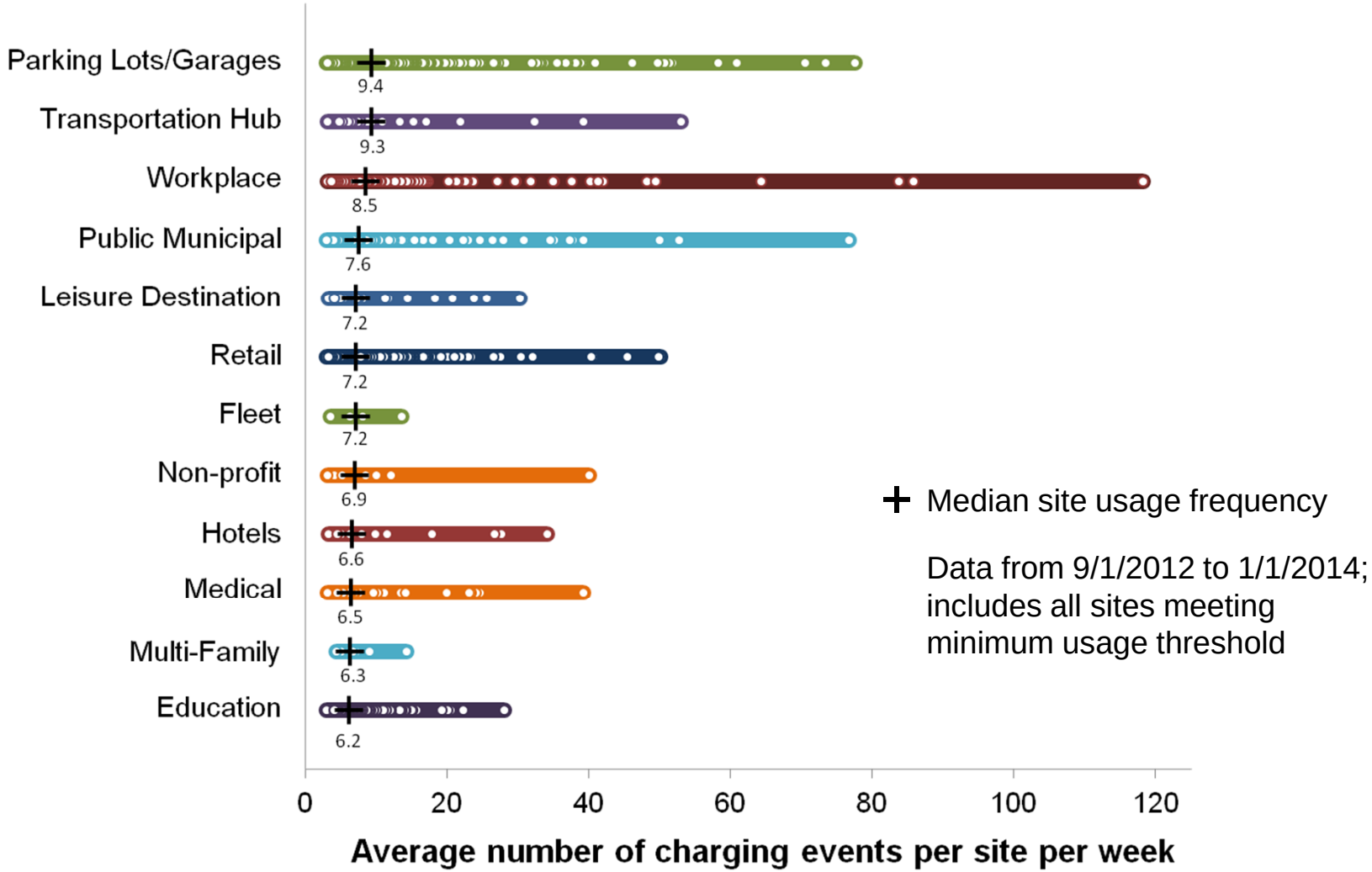
- Which stations are used most frequently?
  - By region and EVSE make
  - By charging level and venue
- Determining hot spots using vehicle data
  - Bay Area examples
- I5 Corridor EVSE usage preview

Public EVSE Sites Exceeding Minimum Usage Threshold by Region and EVSE make

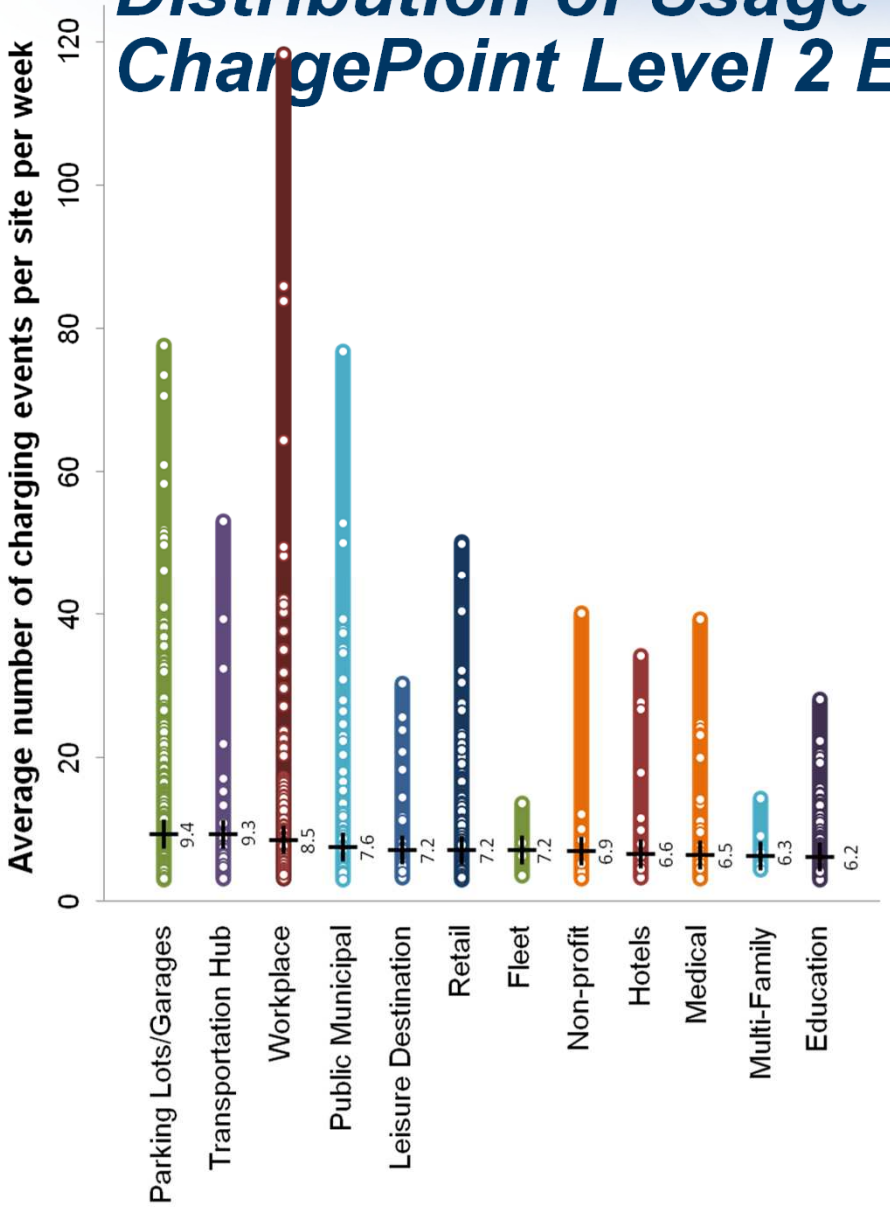


Min usage threshold is > 3 events per site per week

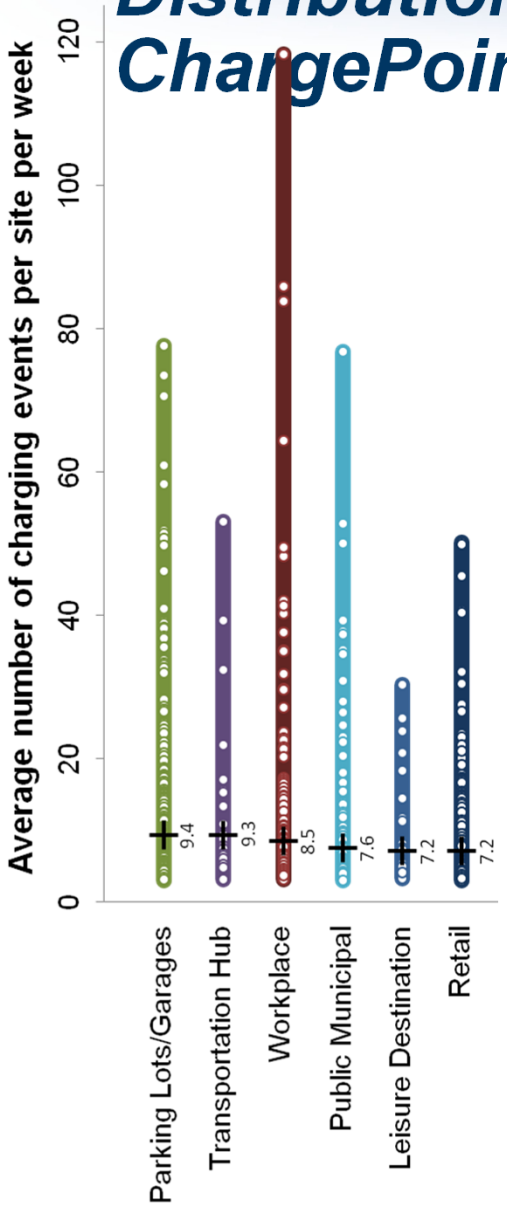
Distribution of Usage Frequency of Blink & ChargePoint Level 2 EVSE Sites by Venue



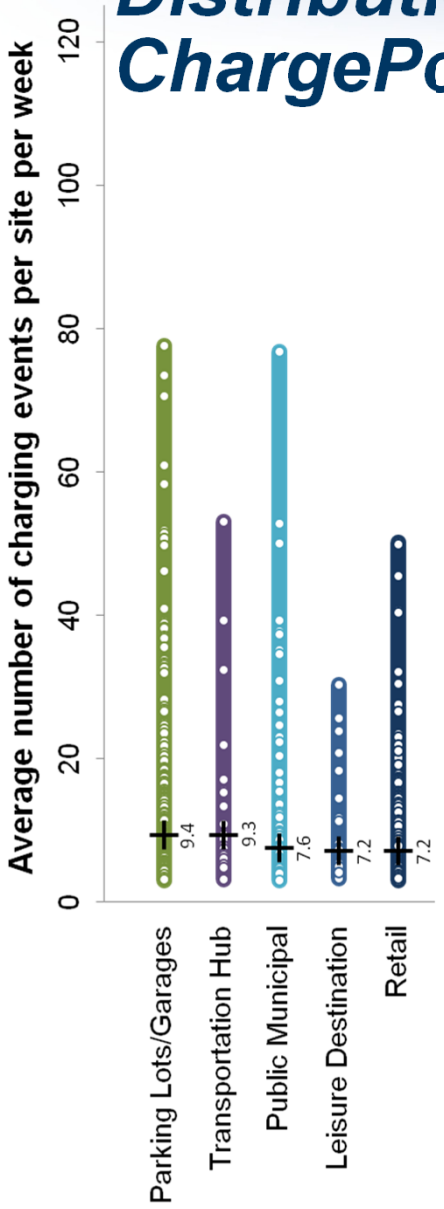
Distribution of Usage Frequency of Blink & ChargePoint Level 2 EVSE Sites by Venue



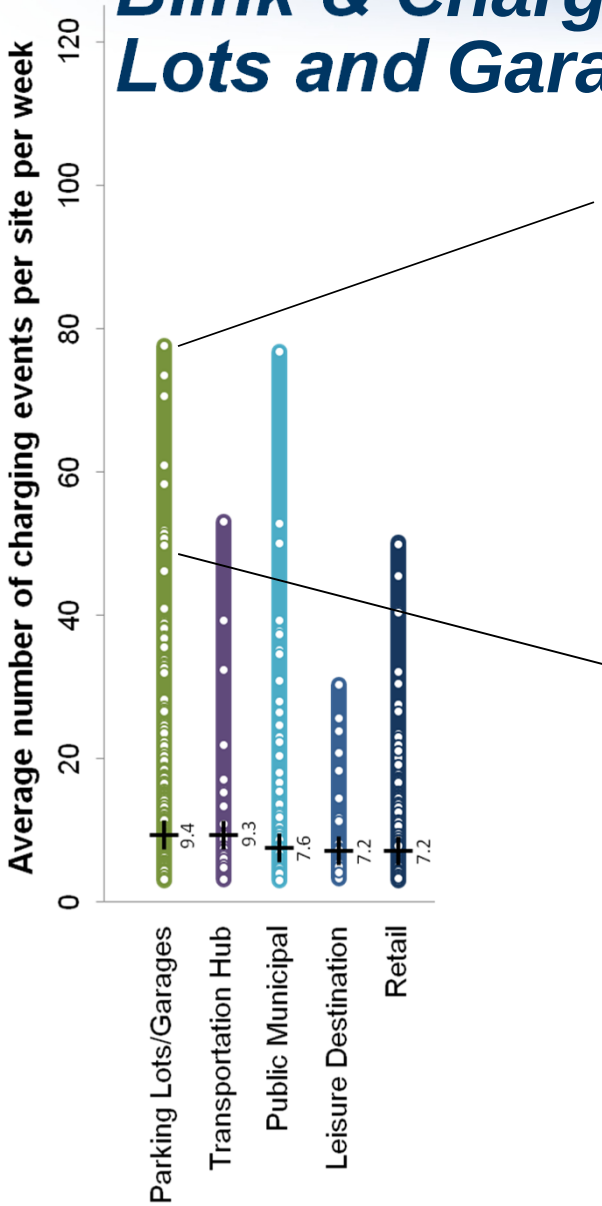
Distribution of Usage Frequency of Blink & ChargePoint Level 2 EVSE Sites by Venue



Distribution of Usage Frequency of Blink & ChargePoint Level 2 EVSE Sites by Venue

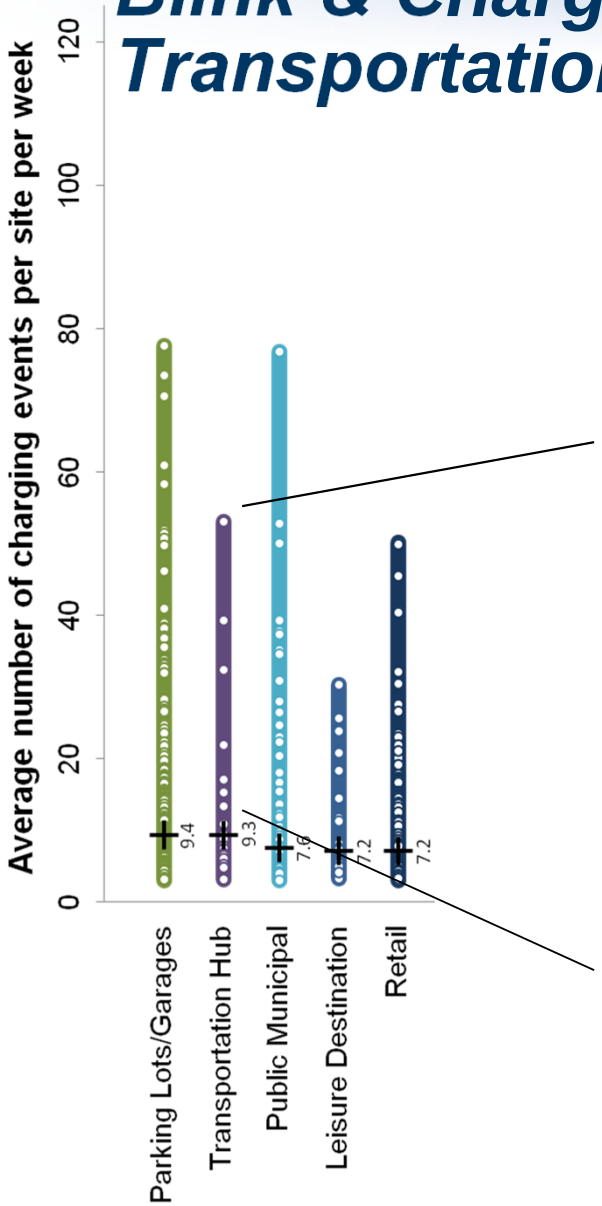


Blink & ChargePoint Level 2 Sites – Parking Lots and Garages



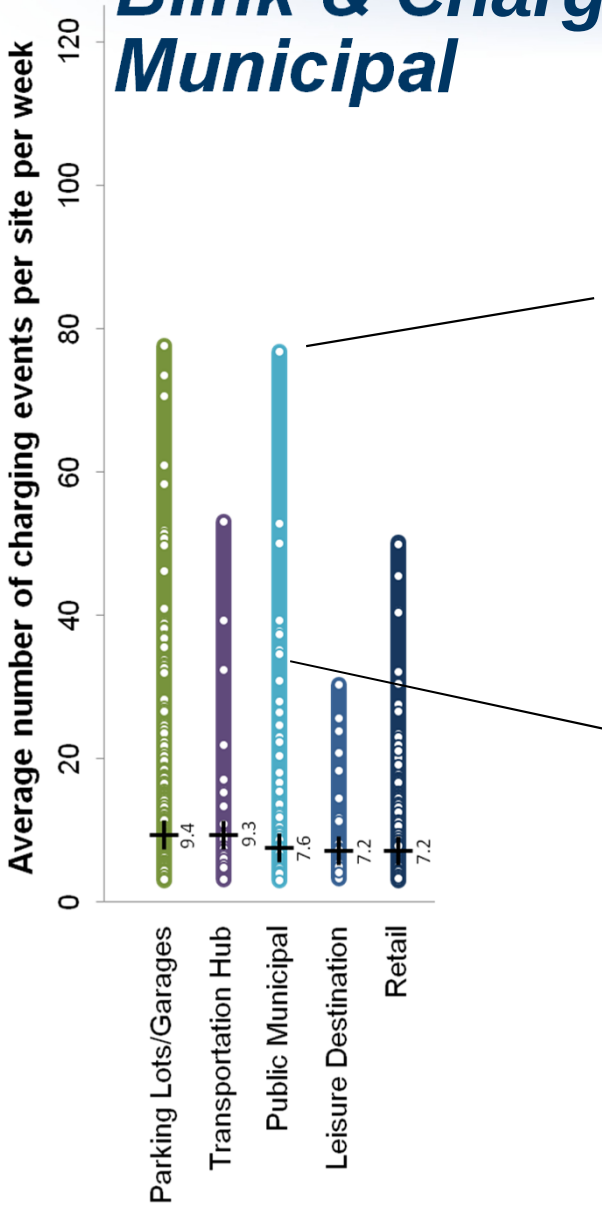
77.5 Downtown Palo Alto
73.4 Fifth & Mission Garage, San Francisco
70.6 Downtown Palo Alto
60.9 Downtown Redwood City
58.3 Parking Structure, Irvine CA
51.8 Parking Structure, Irvine CA
51.4 Parking garage, San Francisco CA
50.7 Sutter Stockton Garage, San Francisco CA

Blink & ChargePoint Level 2 Sites – Transportation Hubs



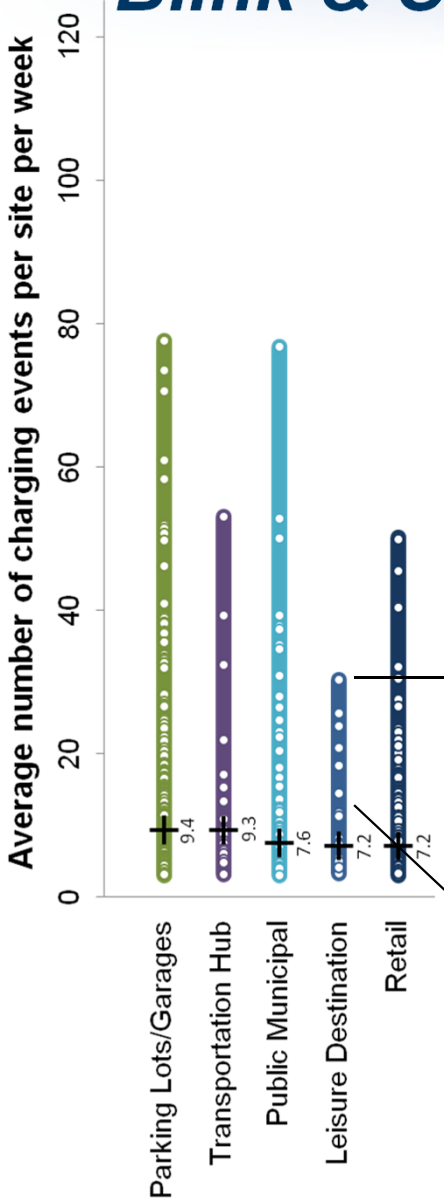
53.0	San Francisco Airport
39.3	Anaheim Canyon Metrolink
32.3	Oceanside Transit Center Metrolink train /light-rail/bus station park and ride
21.9	Oakland International Airport parking
17.0	San Francisco Airport
15.6	Expresso Airport Parking, San Leandro CA
15.2	San Francisco Airport
13.3	MBTA Alewife Station, Cambridge MA
10.9	Long Beach airport parking garage; all-electric vehicles can park free at Long Beach Airport.

Blink & ChargePoint Level 2 Sites – Public / Municipal



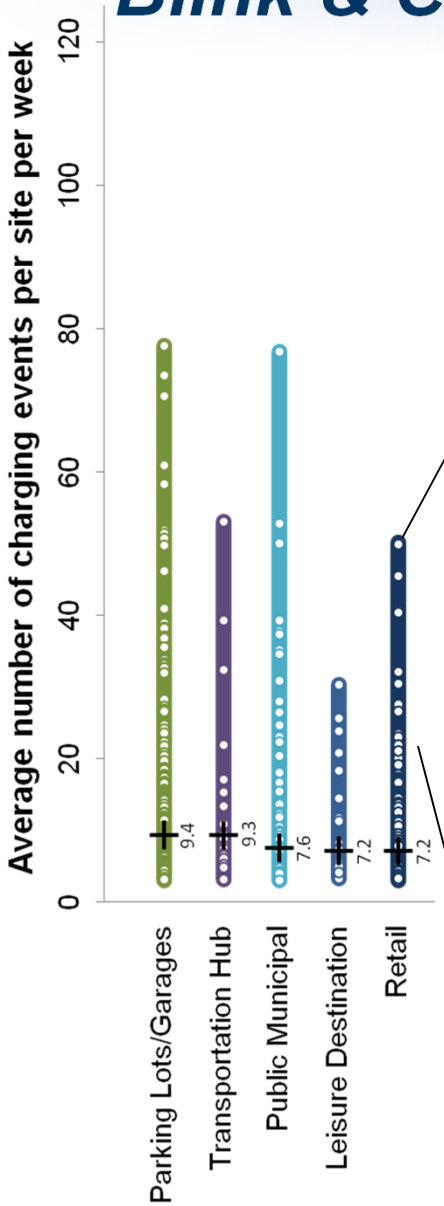
76.7	SCAQMD HQ building, Diamond Bar CA
52.8	City library, Dublin CA
50.0	City library, Redwood City CA
39.3	City hall, Hungtington Beach CA
37.7	Civic center, Campbell CA
37.3	City hall, Hermosa Beach CA
35.1	SCAQMD HQ building, Diamond Bar CA
34.6	City hall, Orange CA

Blink & ChargePoint Level 2 Sites – Leisure



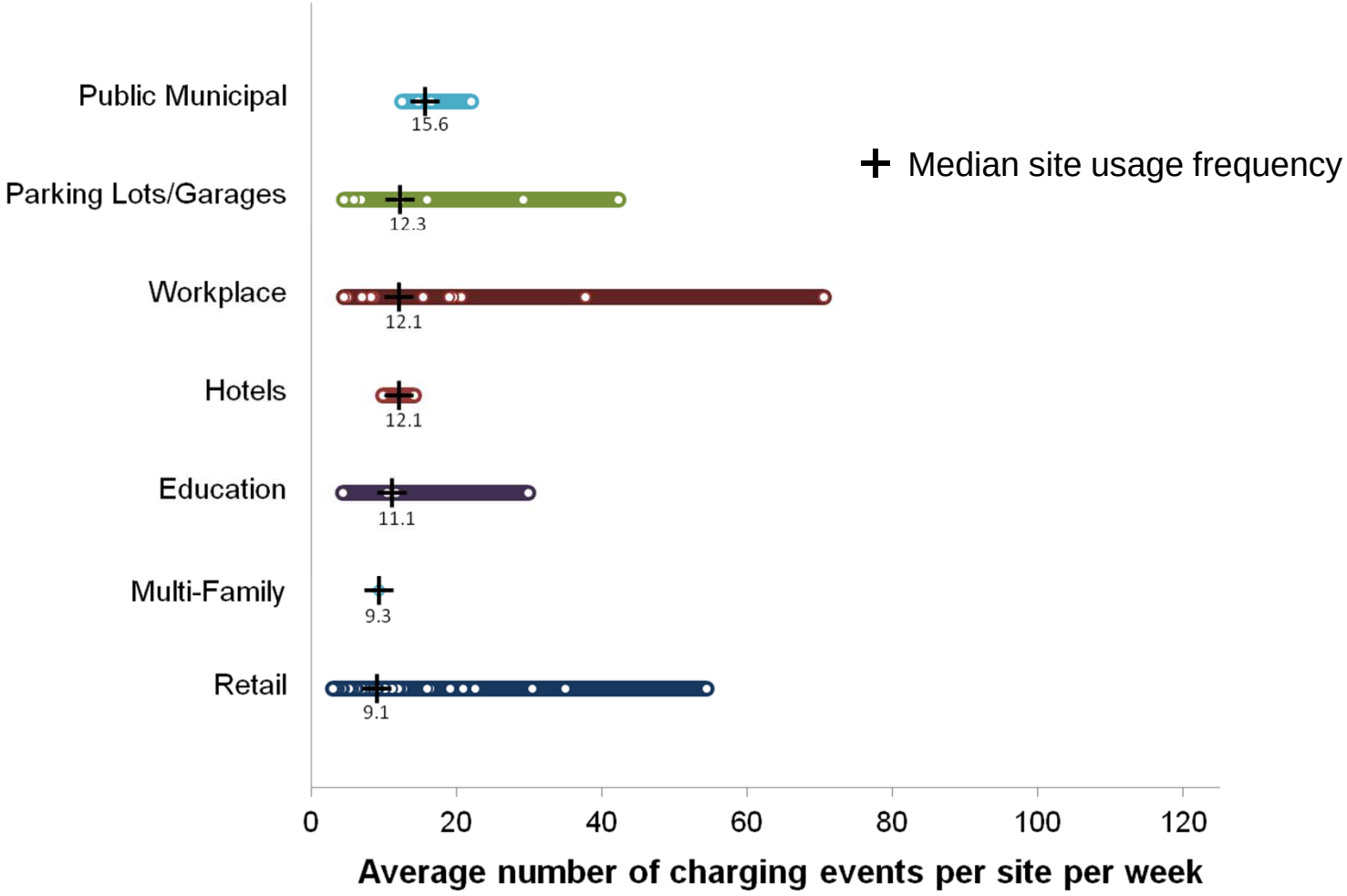
30.3	Rialto Sebastopol Cinemas, Sebastopol CA
25.7	La Cienega Tennis Center, Beverly Hills CA
23.9	Canal Park, Washington DC
20.8	Post Office Square Garage, Boston MA
18.2	Red Morton Community Center, Redwood City CA
14.4	San Diego Zoo
11.7	Balboa Park Air & Space Museum, Automotive Museum, gymnasium, Starlight theatre, etc.

Blink & ChargePoint Level 2 Sites – Retail



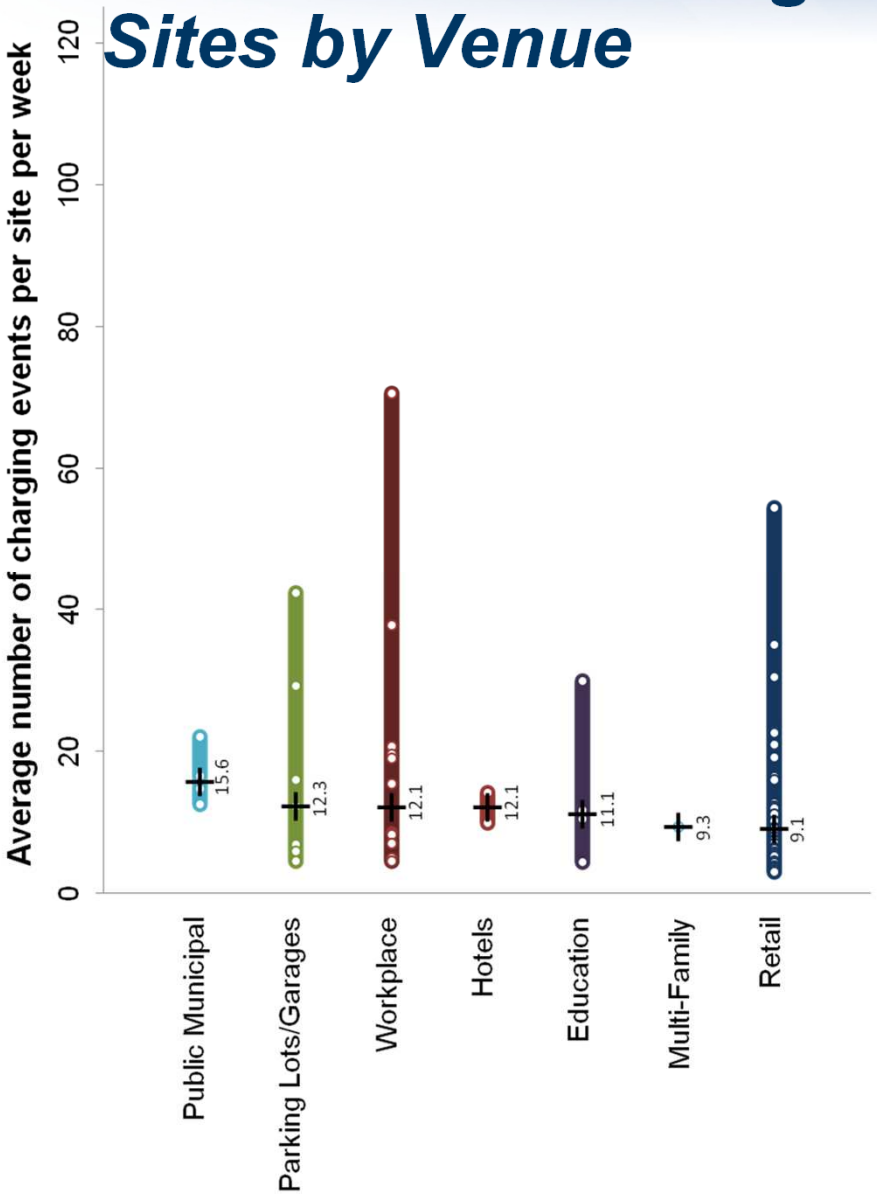
50.1	Retail-Small (Becker Surfboards), Hermosa Beach CA
49.9	Mall (Bella Terra Shopping Ctr), Huntington Beach CA
45.5	Mall (Westfield Galleria Mall), Roseville CA
40.7	Mall (The Grove), Los Angeles CA
40.3	Mall (The Americana at Brand), Glendale CA
32.1	Mall (Stanford Shopping Center), Palo Alto CA
30.4	Mall, Beverly Hills CA
27.5	Mall (Fashion Valley Mall), San Diego CA
26.6	Retail-Small (Ralph's grocery store), Marina Del Ray CA
23.4	Retail-Small (Mollie Stone's Market grocery store), Saulsalito CA
23.0	Retail-Big (Kohl's), Yorba Linda CA
22.8	Electric Lodge Performing Arts Center (dance and fitness center), Venice CA

Distribution of Usage Frequency of Blink DCFC Sites by Venue

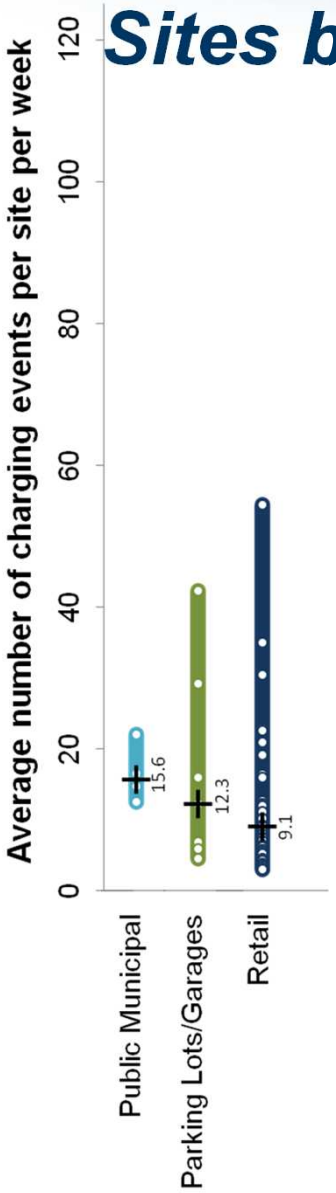


8/1/2013 to 1/1/2014 (after Blink network fees were instituted)

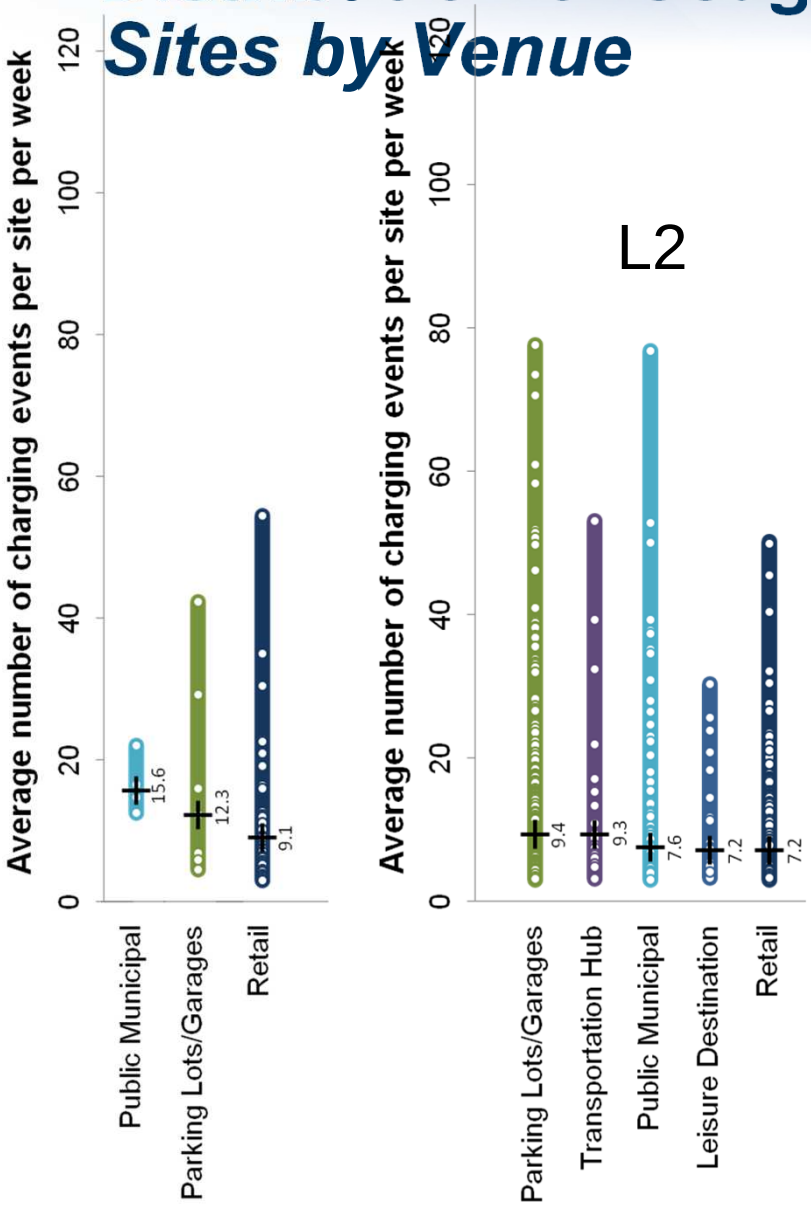
Distribution of Usage Frequency of Blink DCFC Sites by Venue



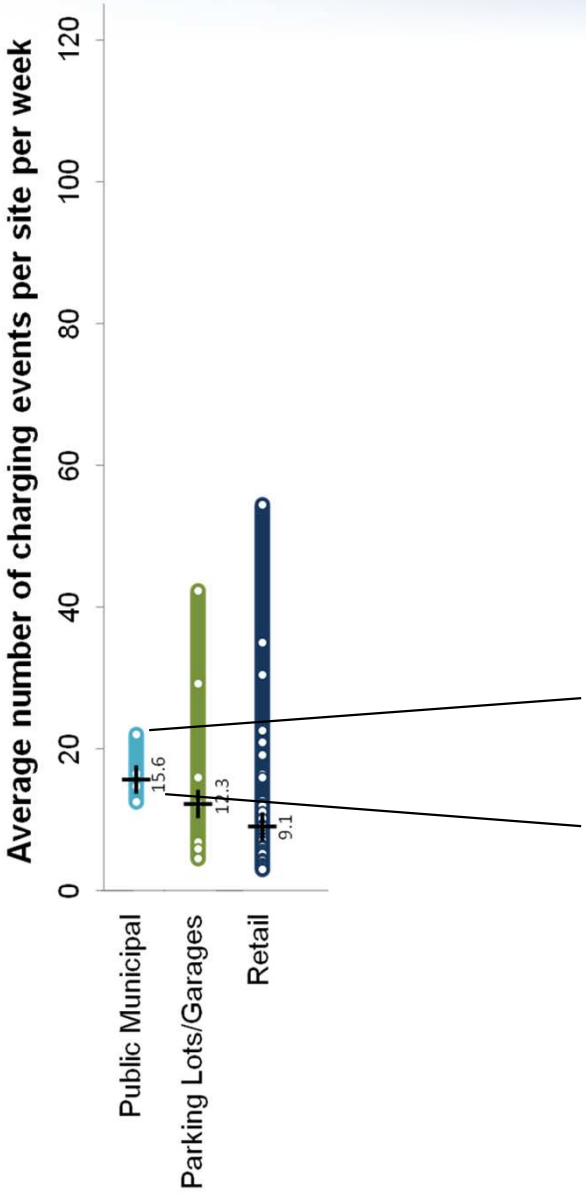
Distribution of Usage Frequency of Blink DCFC Sites by Venue



Distribution of Usage Frequency of Blink DCFC Sites by Venue



Blink DCFC Sites – Public / Municipal

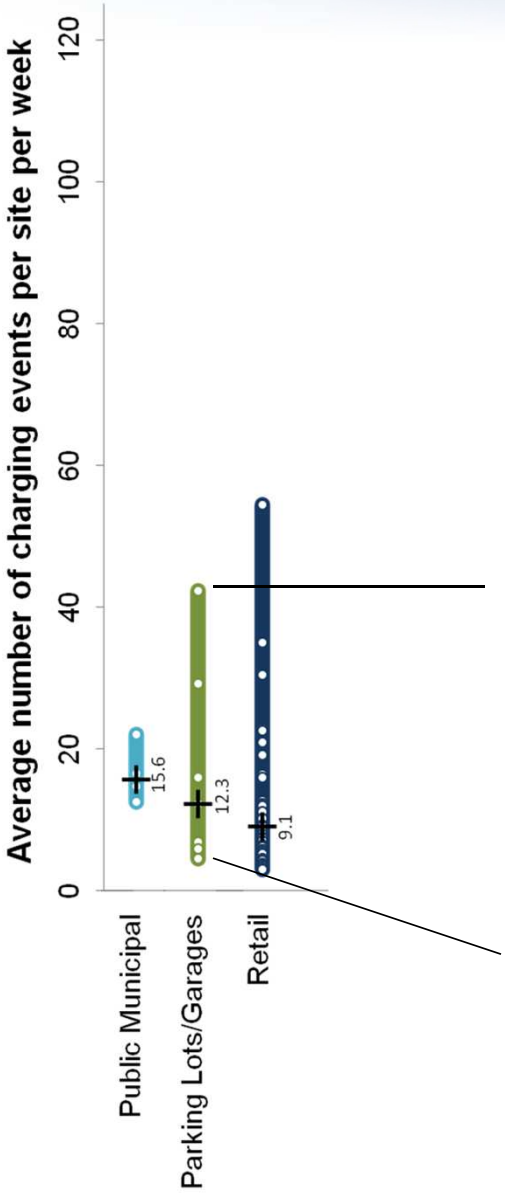


22.0 City hall , Hayward CA

16.6 South Coast AQMD HQ, Diamond Bar CA

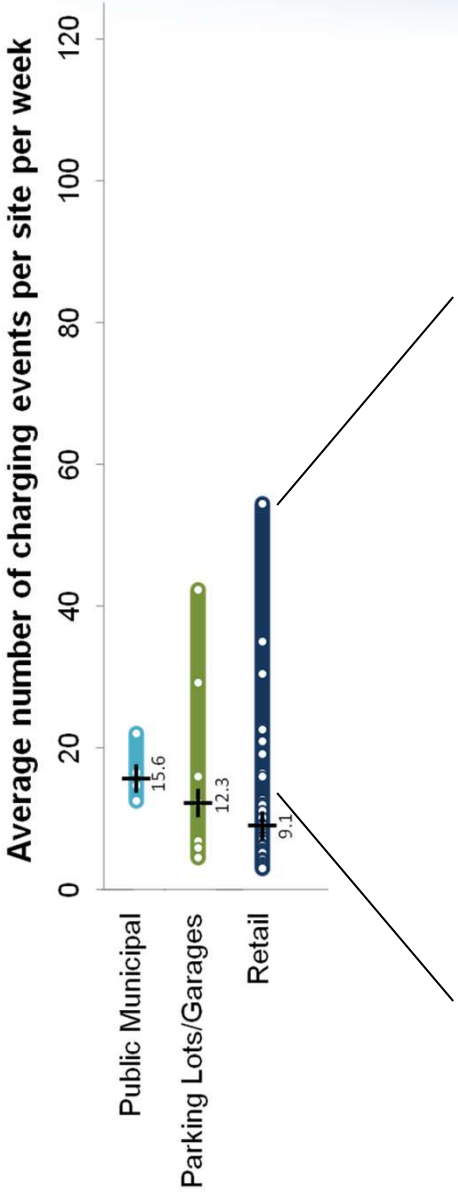
12.5 Petaluma Visitors Center near 101, Petaluma CA

Blink DCFC Sites – Parking Lots and Garages



42.3	Downtown Seattle WA
29.2	Downtown Seattle WA
16.0	Downtown Los Angeles CA
12.3	Public Library, park, shopping center, Santa Clara CA
6.9	Public parking, Azusa CA
5.9	Downtown San Francisco CA
4.6	Business park, South San Francisco CA

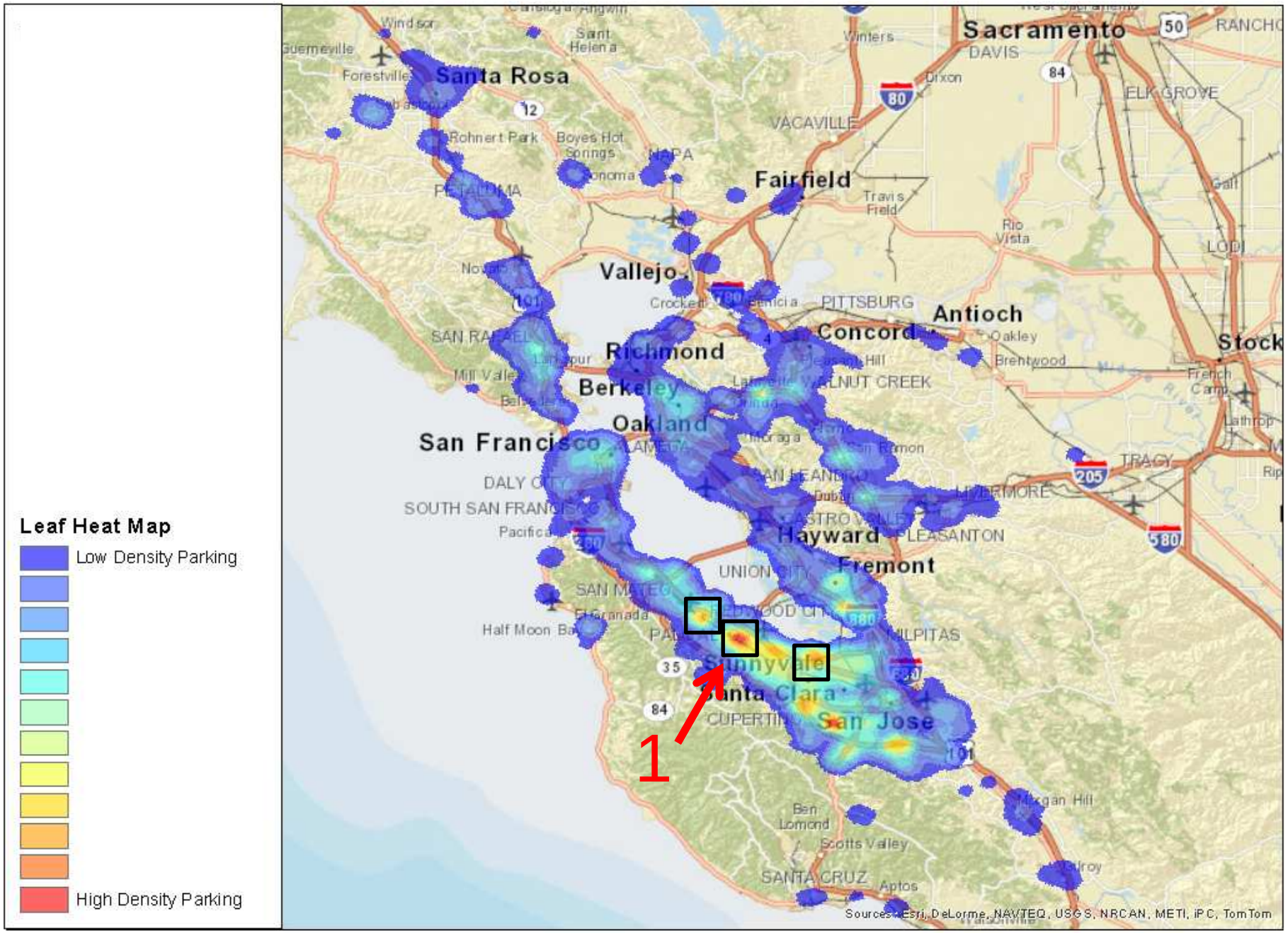
Blink DCFC Sites – Retail

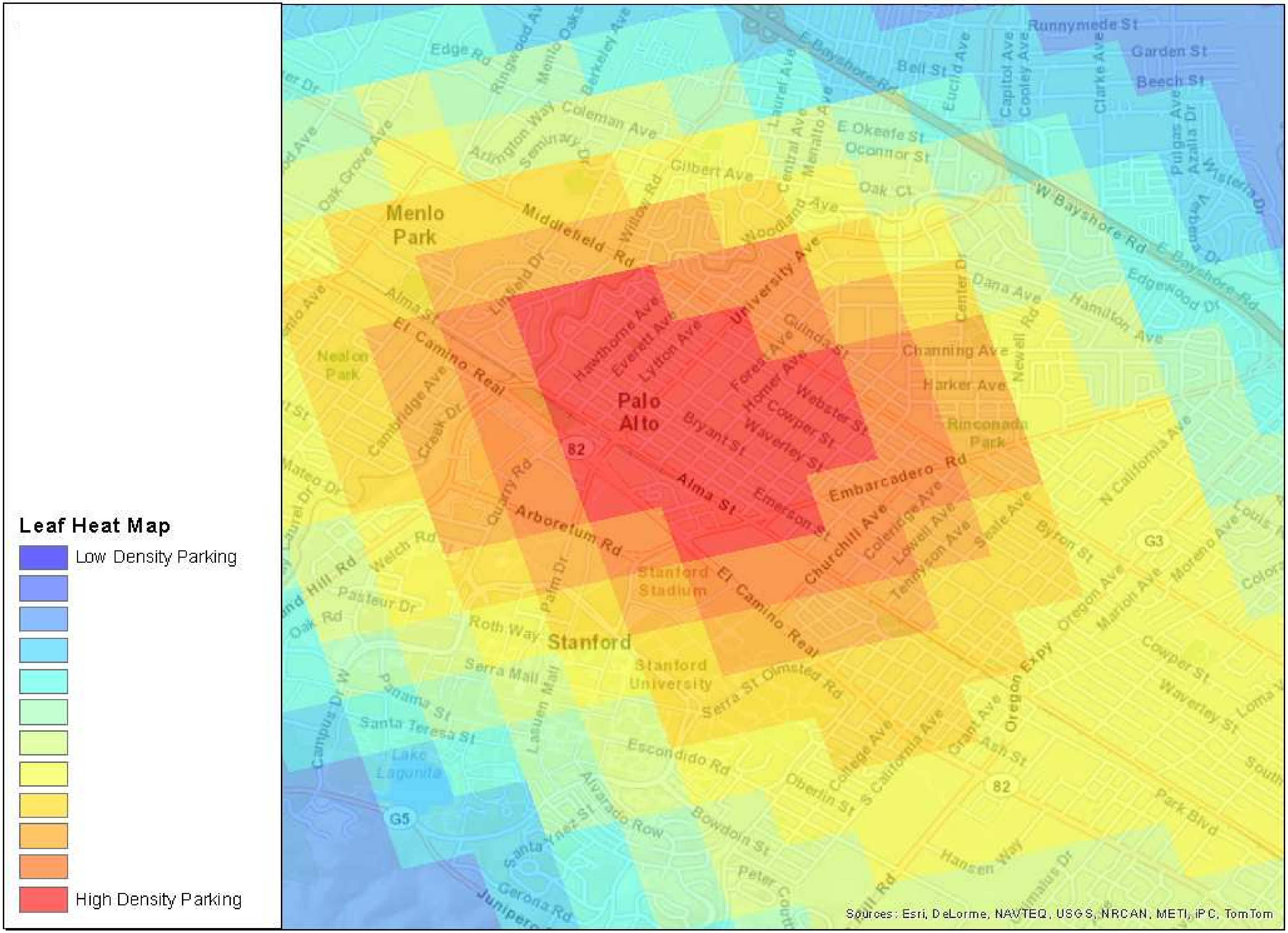


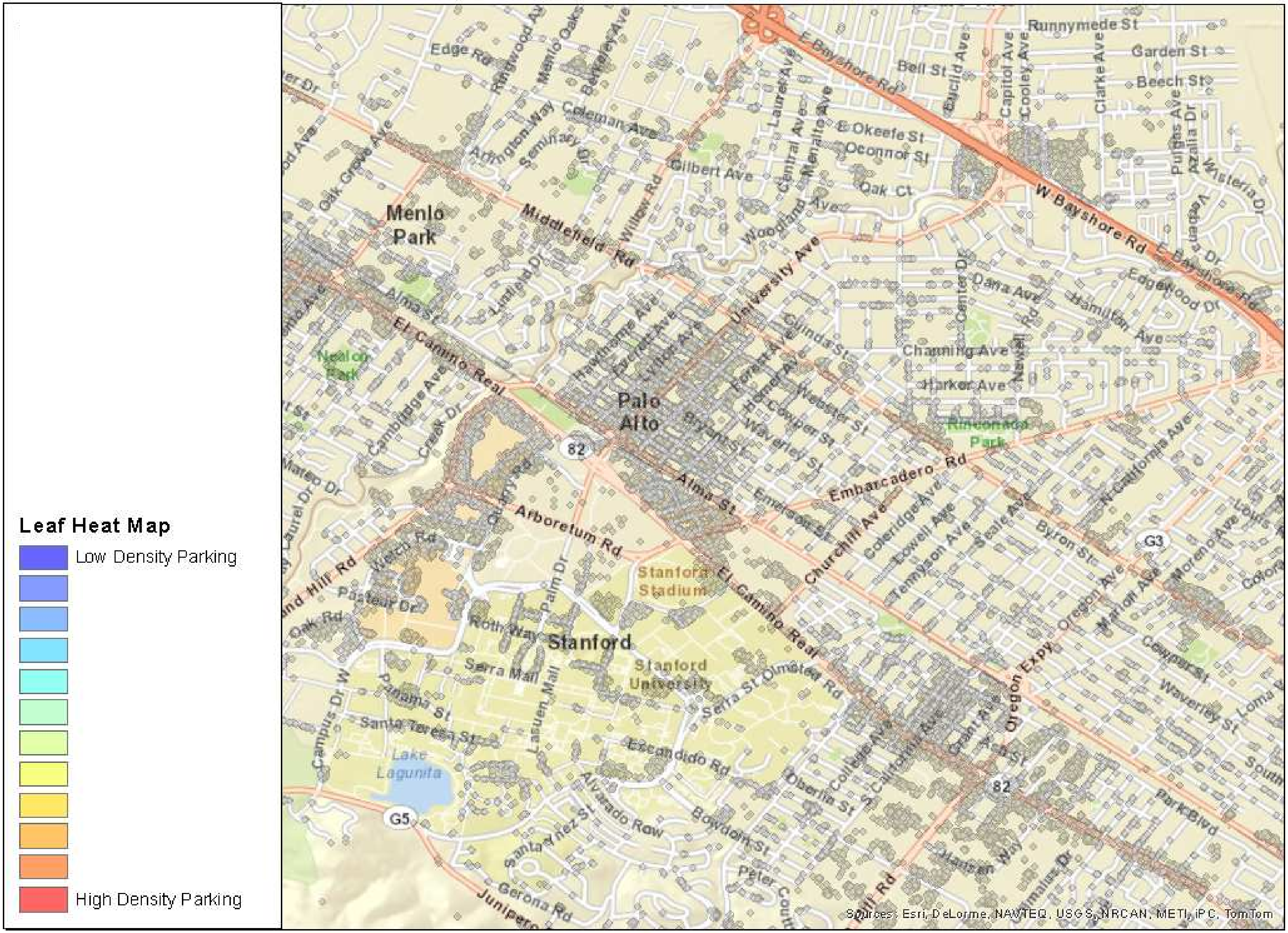
54.4	Tahoma Market on I5, Tacoma WA
35.0	Fred Meyer, Kirkland WA
30.4	Nissan dealership, Bellevue WA
23.1	Fred Meyer, Hillsboro OR
22.8	Fred Meyer, Seattle WA
22.6	Mall on I205, Happy Valley OR
20.9	Fred Meyer, Salem OR
19.1	Fred Meyer, Portland OR
16.5	Nissan dealership, Santa Rosa CA
16.4	Shopping center near I5, Wilsonville OR
16.0	United Markets (grocery store), San Rafael CA
12.7	Nissan dealership, Petaluma CA

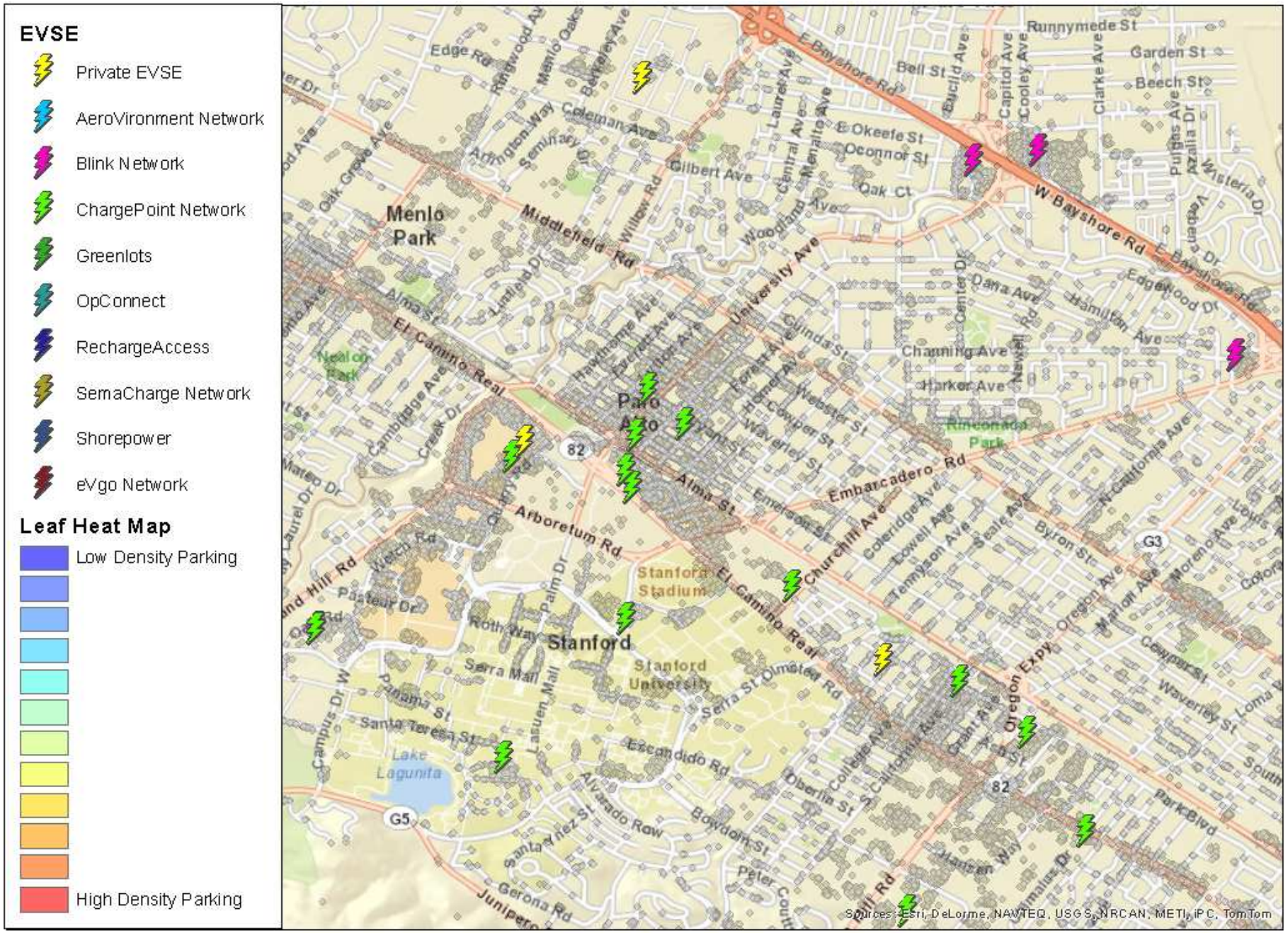
Identifying Hot Spots Using Vehicle Data

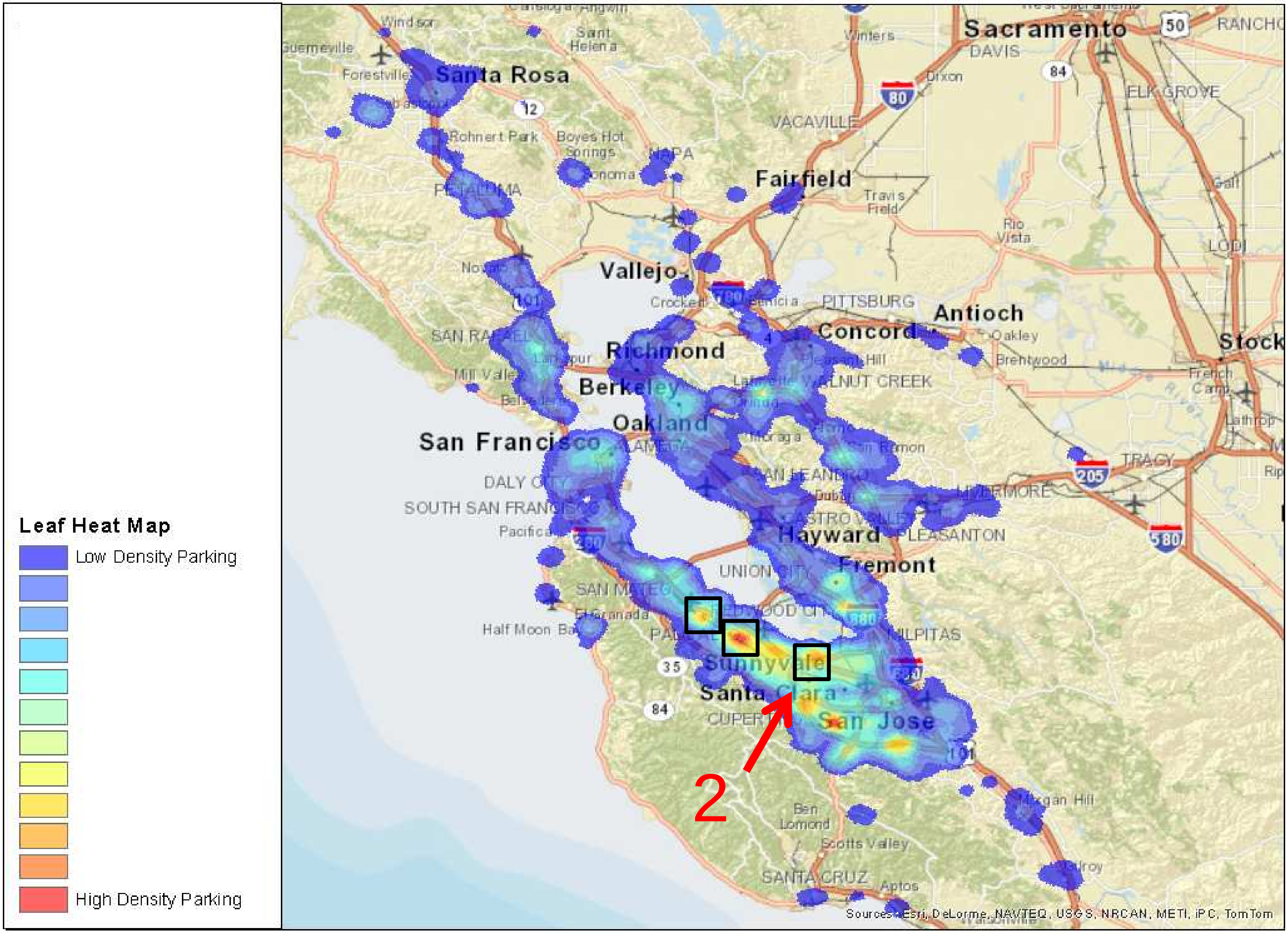
- EV Project Leaf away-from-home parking location density in San Francisco Bay Area
- Cumulative through the end of 2013

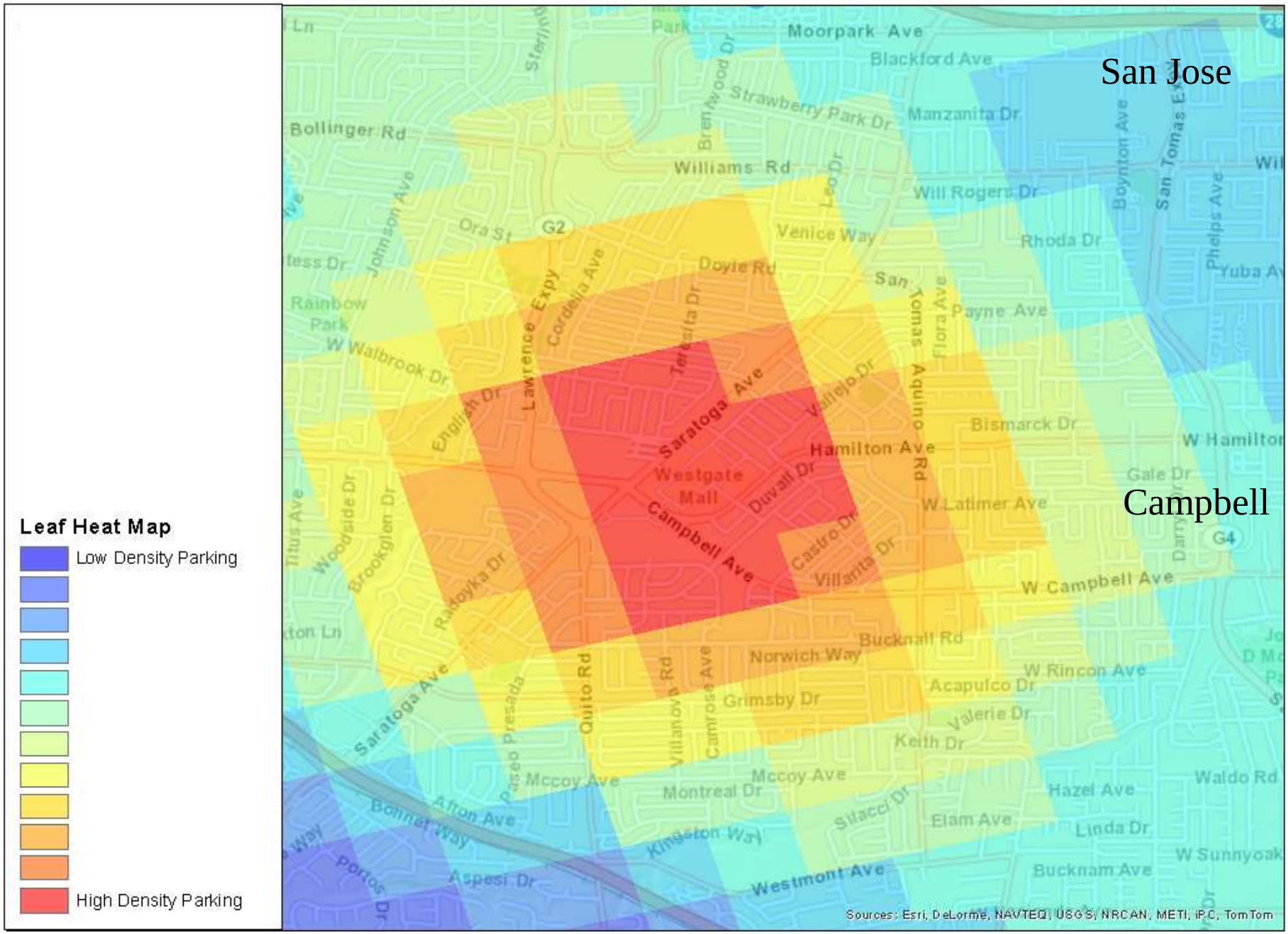

Leaf Heat Map
Low Density Parking
High Density Parking
Santa Rosa
Sacramento
DAVIS
Fairfield
VACAVILLE
Vallejo
Richmond
Berkeley
Oakland
San Francisco
Concord
Antioch
PITTSBURG
Hayward
Fremont
San Jose
Sunnyvale
Santa Clara
SANTA CRUZ
1
Sources: Esri, DeLorme, NAVTEQ, USGS, NRCAN, METI, iPC, TomTom

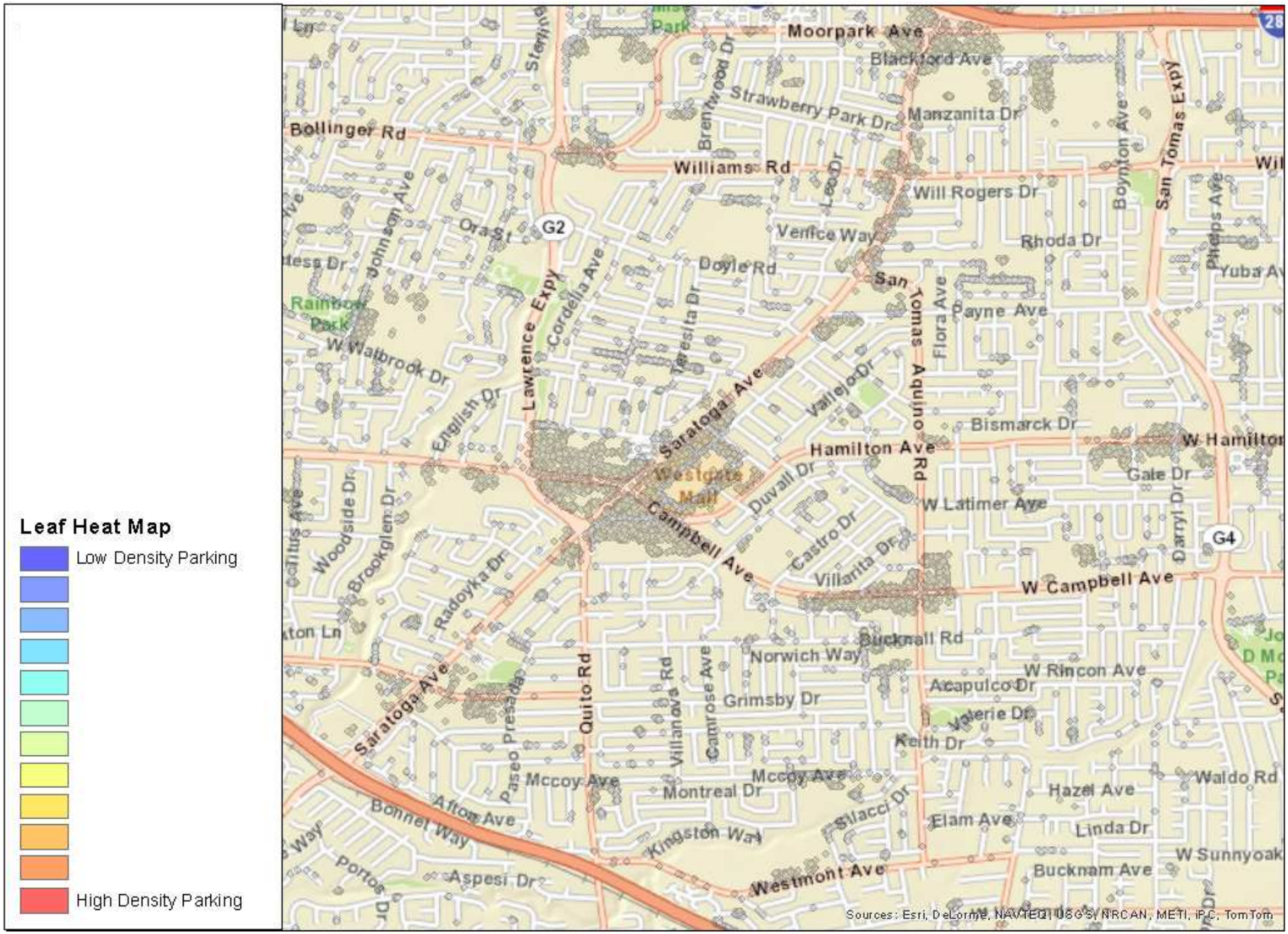

Leaf Heat Map
Low Density Parking
High Density Parking
Menlo Park
Palo Alto
Stanford
Stanford University
Stanford Stadium
Rinconada Park
El Camino Real
Middlefield Rd
University Ave
Embarcadero Rd
Alma St
Arboretum Rd
Oregon Expy
Sources: Esri, DeLorme, NAVTEQ, USGS, NRCAN, METI, iPC, TomTom

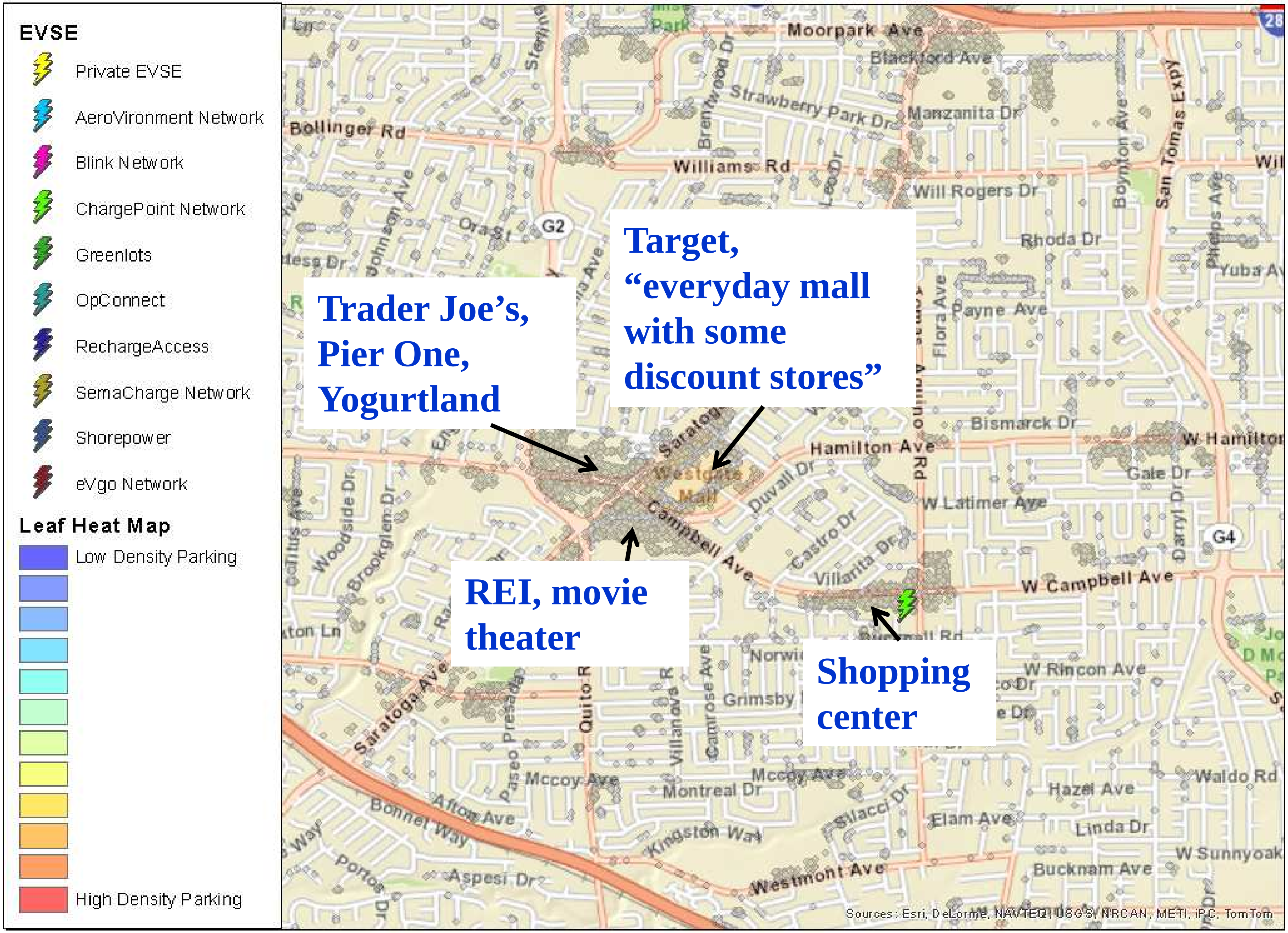

Leaf Heat Map
Low Density Parking
High Density Parking
Menlo Park
Palo Alto
Stanford
Stanford University
Stanford Stadium
Lake Lagunita
Rinconada Park
El Camino Real
Middlefield Rd
University Ave
Embarcadero Rd
Alma St
W Bayshore Rd
E Bayshore Rd
Oregon Expy
Arboretum Rd
Sources: Esri, DeLorme, NAVTEQ, USGS, NRCAN, METI, iPC, TomTom

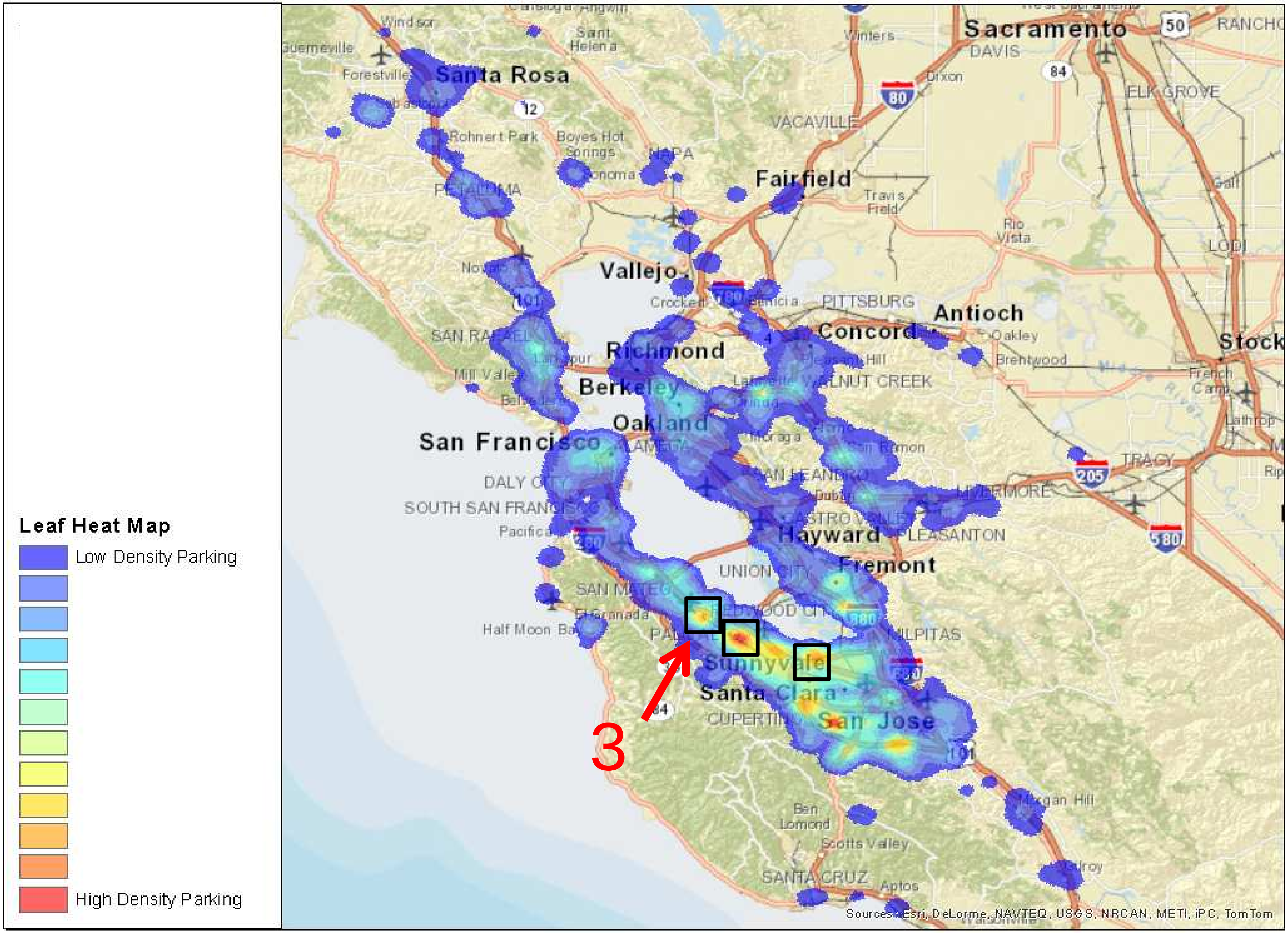

EVSE
Private EVSE
AeroVironment Network
Blink Network
ChargePoint Network
Greenlots
OpConnect
RechargeAccess
SemaCharge Network
Shorepower
eVgo Network
Leaf Heat Map
Low Density Parking
High Density Parking
Menlo Park
Palo Alto
Stanford
Stanford Stadium
Stanford University
Lake Lagunita
Rinconada Park
Nealon Park
Sources: Esri, DeLorme, NAVTEQ, USGS, NRCAN, METI, iPC, TomTom

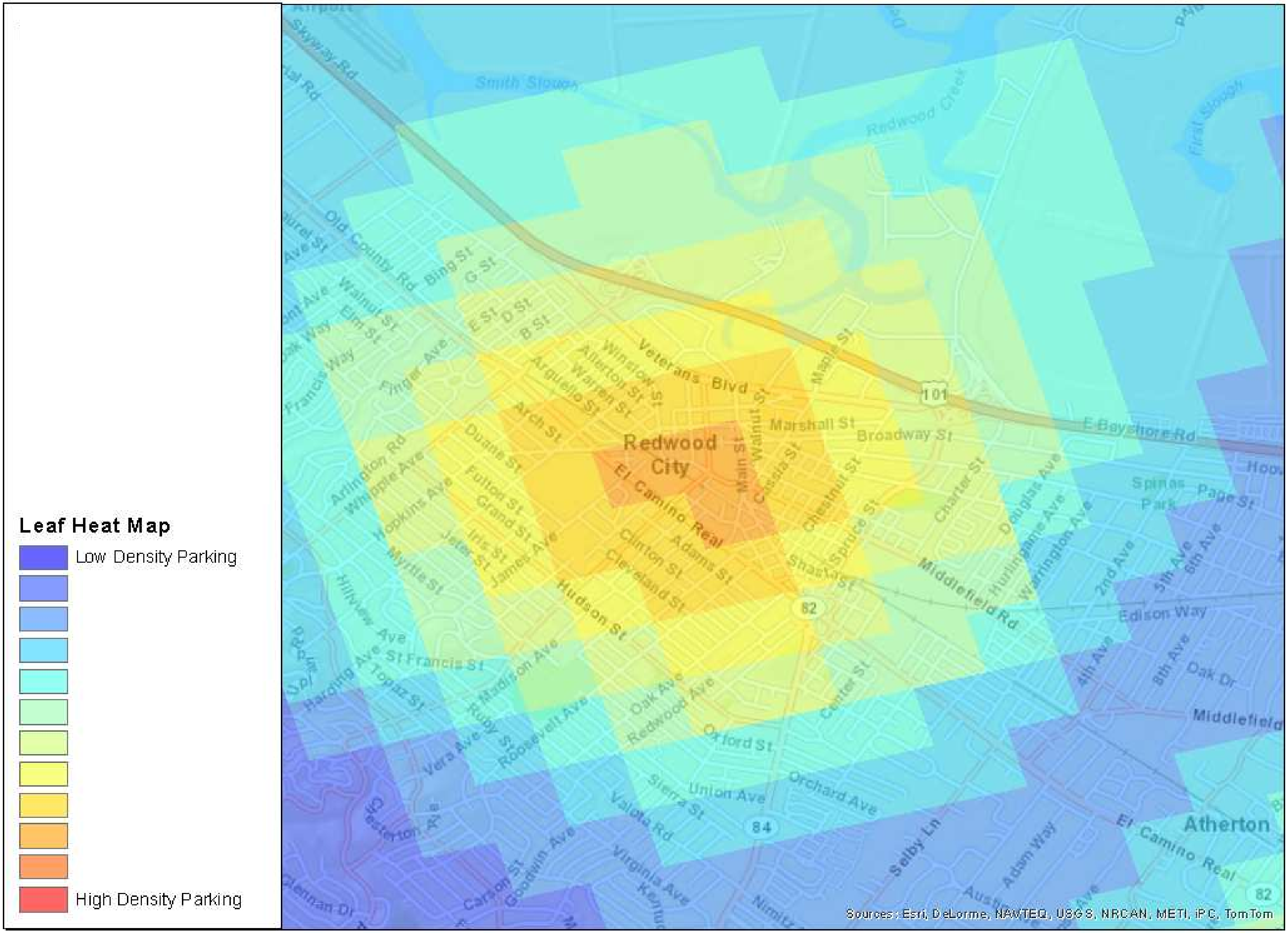

Leaf Heat Map
Low Density Parking
High Density Parking
Santa Rosa
Sacramento
DAVIS
Winters
Dixon
VACAVILLE
ELK GROVE
Fairfield
Rohnert Park
Boyes Hot Springs
NAPA
PETALUMA
Travis Field
Rio Vista
LODI
Vallejo
Crockett
PITTSBURG
Antioch
Concord
Oakley
Brentwood
Richmond
SAN RAFAEL
Mill Valley
Berkeley
WALNUT CREEK
Oakland
San Francisco
DALY CITY
SOUTH SAN FRANCISCO
Pacifica
Stock
French Camp
Lathrop
TRACY
LIVERMORE
Hayward
PLEASANTON
UNION CITY
Fremont
SAN MATEO
El Granada
Half Moon Bay
MILPITAS
Sunnyvale
Santa Clara
San Jose
CUPERTINO
Ben Lomond
Scotts Valley
SANTA CRUZ
Aptos
Morgan Hill
Gilroy
2
Sources: Esri, DeLorme, NAVTEQ, USGS, NRCAN, METI, iPC, TomTom

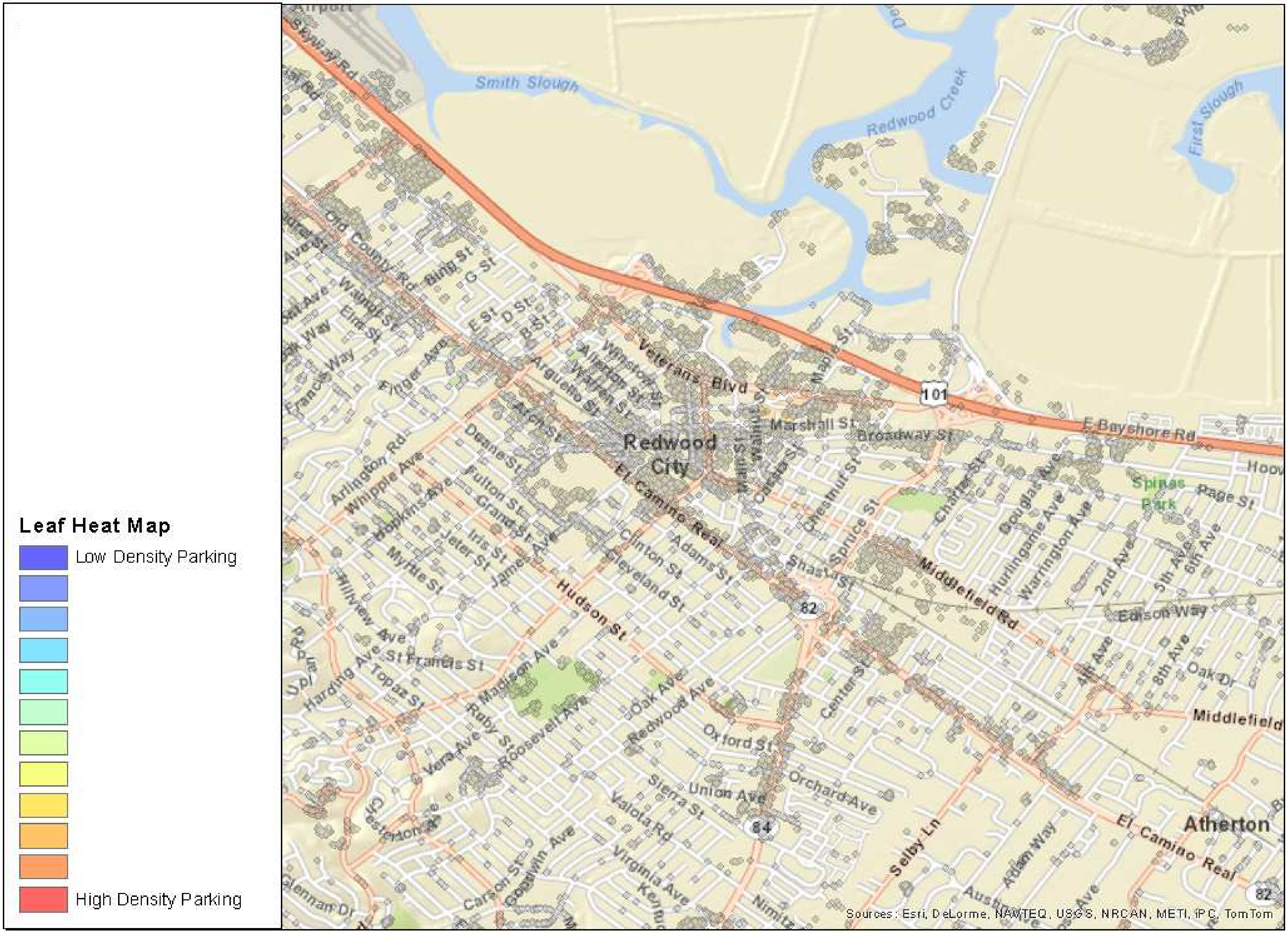

Leaf Heat Map
Low Density Parking
High Density Parking
San Jose
Campbell
Moorpark Ave
Blackford Ave
Strawberry Park Dr
Manzanita Dr
Bollinger Rd
Williams Rd
Will Rogers Dr
Venice Way
Rhoda Dr
Doyle Rd
Payne Ave
Rainbow Park
W Walbrook Dr
Saratoga Ave
Hamilton Ave
Westgate Mall
Campbell Ave
Bismarck Dr
W Latimer Ave
W Campbell Ave
Bucknall Rd
Norwich Way
Grimsby Dr
Acapulco Dr
W Rincon Ave
Keith Dr
Valerie Dr
Mccoy Ave
Montreal Dr
Hazel Ave
Elam Ave
Linda Dr
Bucknam Ave
Westmont Ave
Kingston Way
Afton Ave
Bonnet Way
Aspesi Dr
Waldo Rd
W Sunnyoak
Gale Dr
W Hamilton
Lawrence Expy
San Tomas Aquino Rd
Quito Rd
Sources: Esri, DeLorme, NAVTEQ, USGS, NRCAN, METI, iPC, TomTom

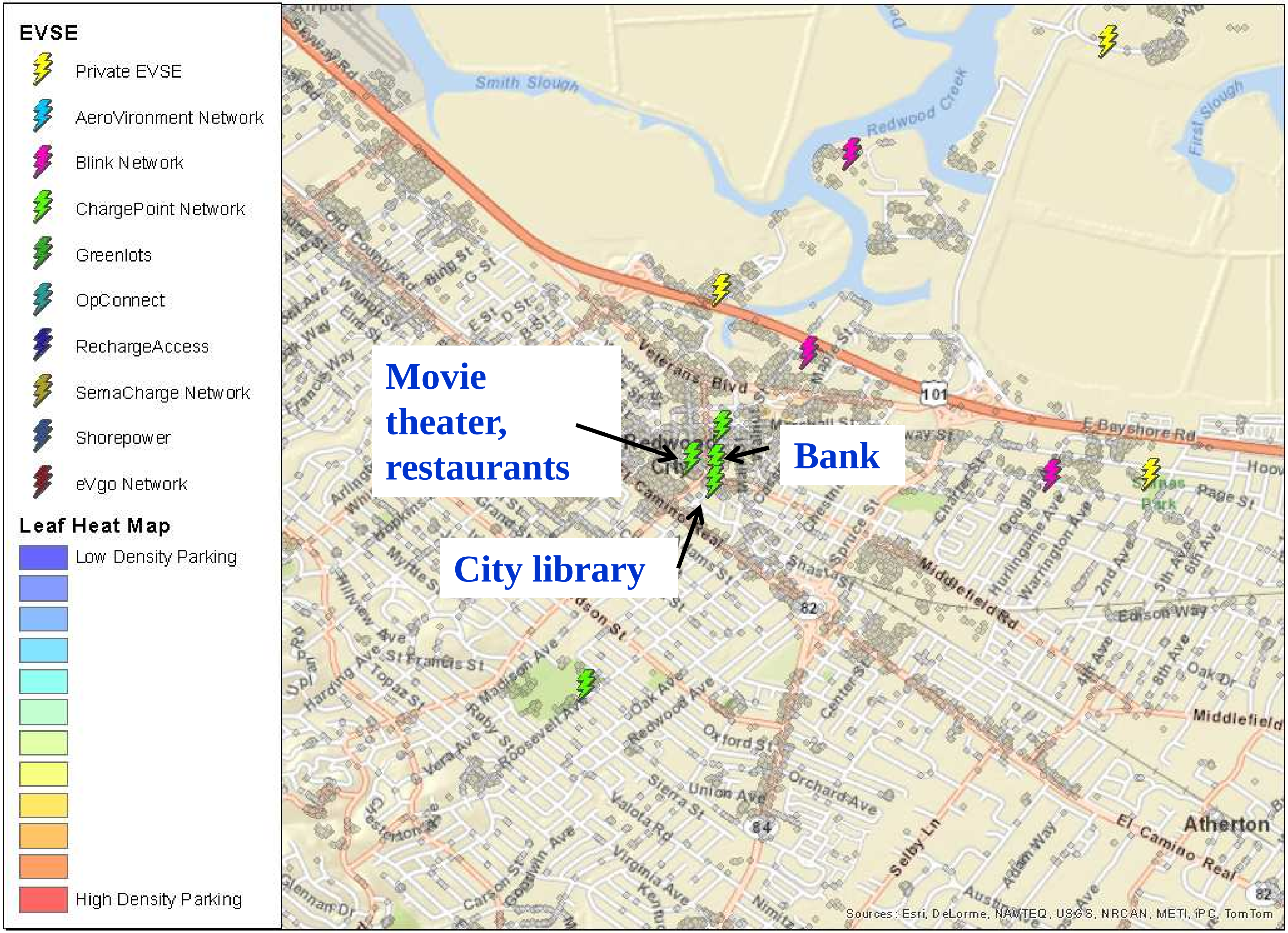

Leaf Heat Map
Low Density Parking
High Density Parking
Moorpark Ave
Blackford Ave
Strawberry Park Dr
Manzanita Dr
Bollinger Rd
Williams Rd
Will Rogers Dr
Verrice Way
Rhoda Dr
Doyle Rd
Payne Ave
Bismarck Dr
Hamilton Ave
W Latimer Ave
Gale Dr
Campbell Ave
W Campbell Ave
Villarita Dr
Castro Dr
Duvall Dr
Norwich Way
Bucknall Rd
W Rincon Ave
Acapulco Dr
Valerie Dr
Keith Dr
Grimsby Dr
Mccoy Ave
Montreal Dr
Hazel Ave
Waldo Rd
Elam Ave
Linda Dr
Bucknam Ave
W Sunnyoak
Westmont Ave
Kingston Way
Bonnet Way
Afton Ave
Aspesi Dr
Saratoga Ave
Quito Rd
Villanova Rd
Camrose Ave
Paseo Presada
Radoyka Dr
Brookglen Dr
Woodside Dr
English Dr
W Walbrook Dr
Lawrence Expy
Cordelia Ave
Teresita Dr
Vallejo Dr
San Tomas Aquino Rd
Flora Ave
Darryl Dr
Boynton Ave
San Tomas Expy
Phelps Ave
Yuba Av
Brentwood Dr
Lee Dr
Johnson Ave
Ora St
Rainbow Park
Westgate Mall
G2
G4
Sources: Esri, DeLorme, NAVTEQ, USGS, NRCAN, METI, iPC, TomTom


EVSE
Private EVSE
AeroVironment Network
Blink Network
ChargePoint Network
Greenlots
OpConnect
RechargeAccess
SemaCharge Network
Shorepower
eVgo Network
Leaf Heat Map
Low Density Parking
High Density Parking
Trader Joe's, Pier One, Yogurtland
Target, "everyday mall with some discount stores"
REI, movie theater
Shopping center
Sources: Esri, DeLorme, NAVTEQ, USGS, NRCAN, METI, iPC, TomTom


Leaf Heat Map
Low Density Parking
High Density Parking
3
Santa Rosa
Sacramento
Fairfield
Vallejo
Antioch
Concord
Richmond
Berkeley
Oakland
San Francisco
Hayward
Fremont
Sunnyvale
Santa Clara
San Jose
DALY CITY
SOUTH SAN FRANCISCO
SAN MATEO
UNION CITY
MILPITAS
CUPERTINO
PLEASANTON
LIVERMORE
TRACY
PITTSBURG
VACAVILLE
DAVIS
ELK GROVE
LODI
PETALUMA
Rohnert Park
Half Moon Bay
Morgan Hill
SANTA CRUZ
Scotts Valley
Aptos
Sources: Esri, DeLorme, NAVTEQ, USGS, NRCAN, METI, iPC, TomTom

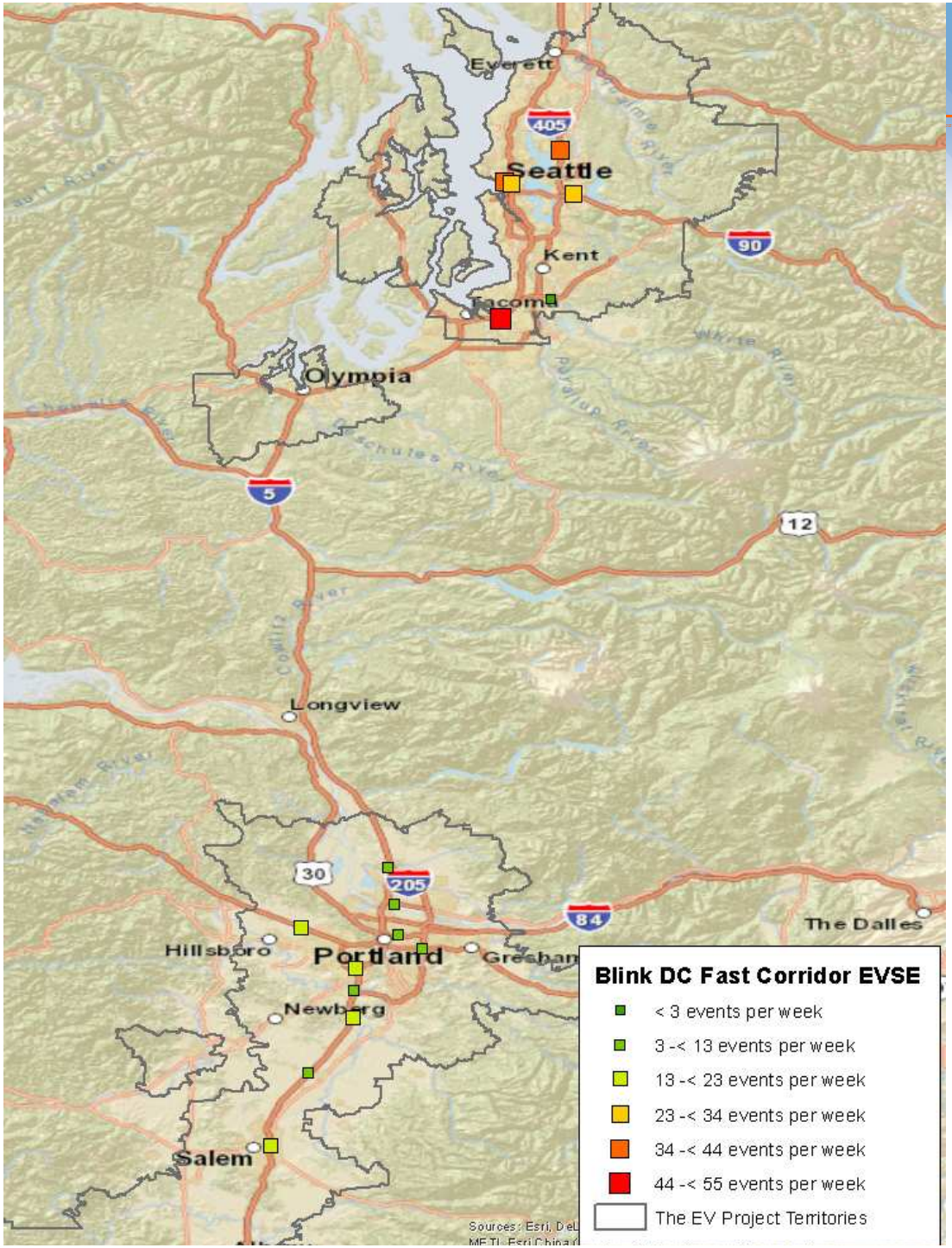

Leaf Heat Map
Low Density Parking
High Density Parking
Redwood City
Atherton
Veterans Blvd
El Camino Real
Marshall St
Broadway St
Middlefield Rd
E Bayshore Rd
Edison Way
Old County Rd
Smith Slough
Redwood Creek
Union Ave
Orchard Ave
Oxford St
Hudson St
Main St
Walnut St
Arch St
Arguello St
Duane St
Fulton St
Grand St
Clinton St
Adams St
Cleveland St
Chestnut St
Spruce St
Charter St
Douglas Ave
Hopkins Ave
Whipple Ave
Arlington Rd
Finger Ave
Madison Ave
Roosevelt Ave
Vera Ave
Topaz St
Harding Ave
Hillview Ave
Myrtle St
St Francis St
Oak Ave
Redwood Ave
Center St
Sierra St
Valota Rd
Virginia Ave
Selby Ln
Adam Way
Oak Dr
Spinas Park
Page St
101
82
84
Sources: Esri, DeLorme, NAVTEQ, USGS, NRCAN, METI, iPC, TomTom

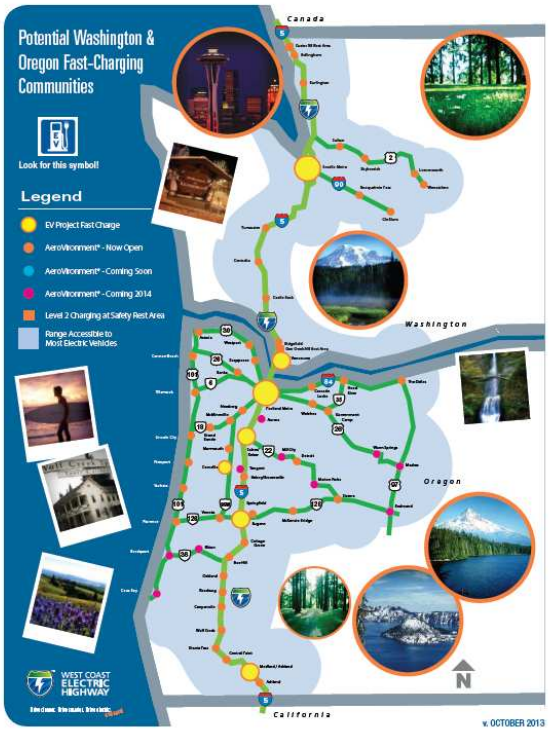

Leaf Heat Map
Low Density Parking
High Density Parking
Smith Slough
Redwood Creek
First Slough
Redwood City
Atherton
Veterans Blvd
Marshall St
Broadway St
E Bayshore Rd
El Camino Real
Middlefield Rd
Edison Way
Hudson St
Old County Rd
Spinas Park
101
82
84
Sources: Esri, DeLorme, NAVTEQ, USGS, NRCAN, METI, iPC, TomTom


EVSE
Private EVSE
AeroVironment Network
Blink Network
ChargePoint Network
Greenlots
OpConnect
RechargeAccess
SemaCharge Network
Shorepower
eVgo Network
Leaf Heat Map
Low Density Parking
High Density Parking
Movie theater, restaurants
Bank
City library
Smith Slough
Redwood Creek
First Slough
Veterans Blvd
E Bayshore Rd
Middlefield Rd
El Camino Real
Atherton
Sources: Esri, DeLorme, NAVTEQ, USGS, NRCAN, METI, iPC, TomTom

Idaho National Laboratory

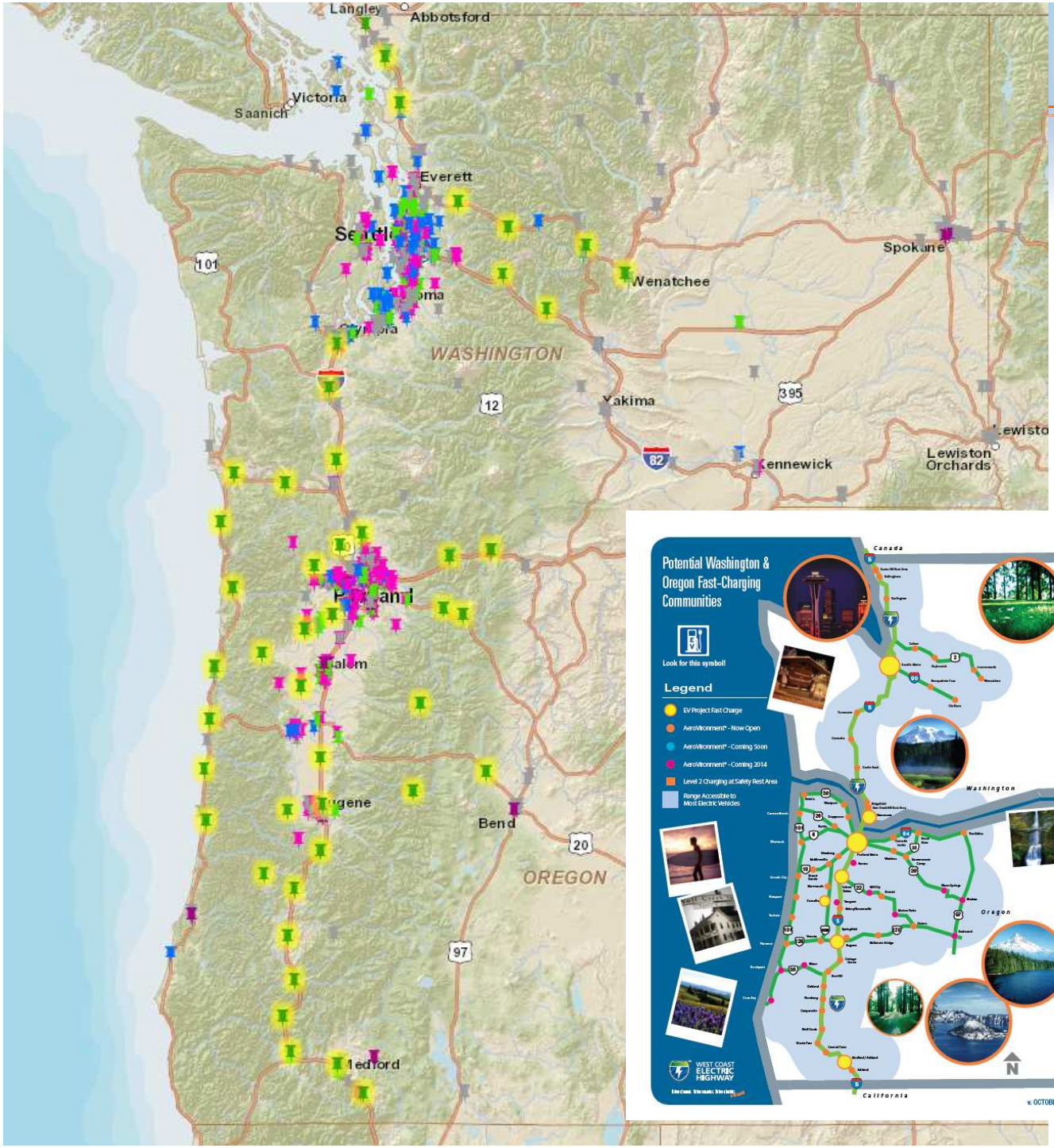
Blink DCFC usage on I-5 Corridor in OR & WA





Idaho National Laboratory

AeroVironment DCFCs near the I-5 Corridor in OR & WA



- AV DCFCs highlighted in yellow
- Other publicly available EVSE sites in blue and purple

Additional Information

Published since last meeting:

- Leaf vs. Volt eVMT
- Workplace charging case study: Facebook Offices, Menlo Park

Publications coming soon:

- Leaf away-from-home infrastructure usage vs. eVMT
- Usage of public EVSE at different venue types
- Additional Workplace charging case studies and driver behavior
- PEV travel on the OR/WA I5 corridor
- EVSE installation costs

For all EV Project and ChargePoint America publications, visit

avt.inl.gov/evproject.shtml

avt.inl.gov/chargepoint.shtml

INL's funding for this work comes from DOE's Vehicle Technologies Office

BACKGROUND INFO

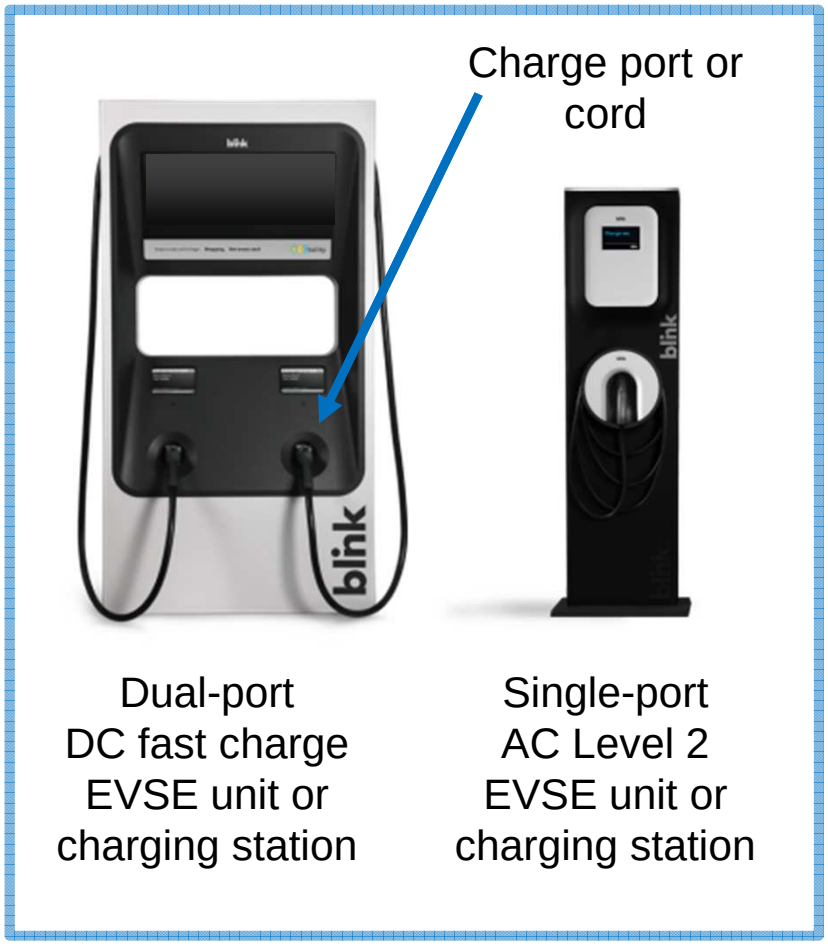
Measures of "Goodness"

There are numerous ways to assess how "good" public charging sites are:

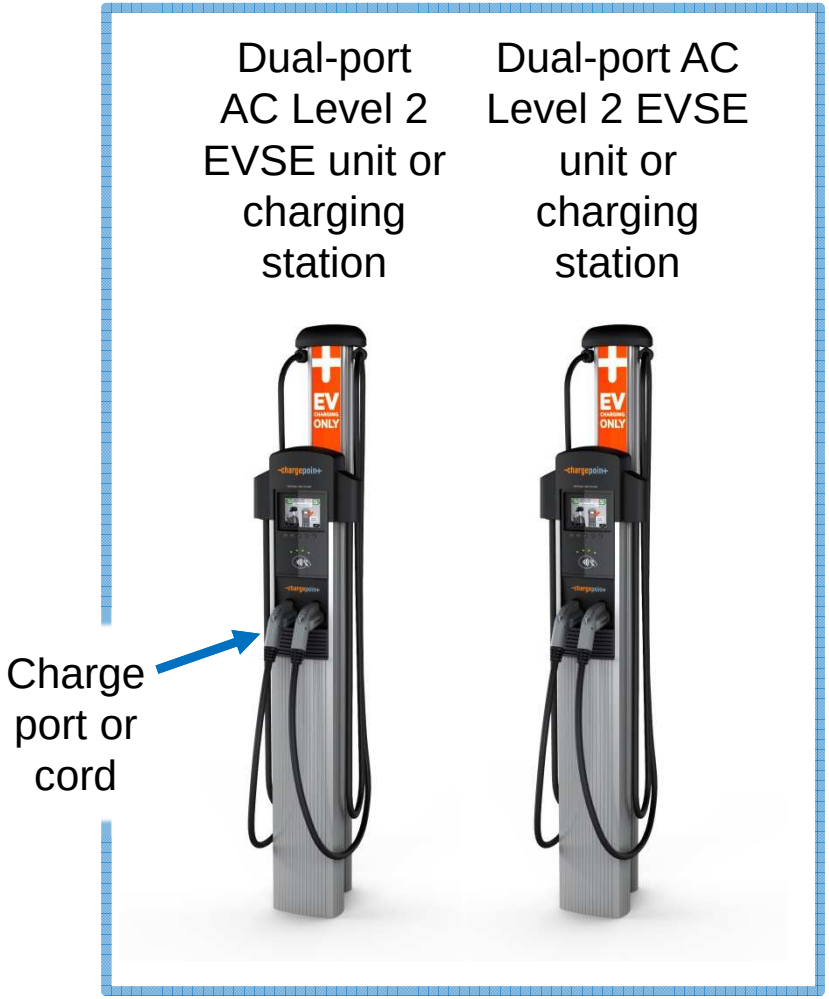
- Charging frequency: number of charge events per day or week
- Charging time: hours connected
- Charging energy: kWh consumed / EV miles provided
- Parking time: time spent in parking space / in store
- Charging site host may want electric vehicle supply equipment (EVSE) for other reasons, such as image or cool factor
- etc.

Terminology

Charging site



Charging site



Public EVSE Usage Fees

Blink usage fees

- Public AC Level 2 fees started Jul – Aug 2012
  - Varies from $1.00 to $2.00 **per hour connected**
  - 16% of sites were still free as of Dec 31, 2013 (per local site host discretion)
- DC Fast Charger fees started Jul 2013
  - $5 for Blink member / $8 for non-member **per session**

ChargePoint usage fees

- Vary by site (per local site host discretion)
- Many are free

Charging Site Location Considerations

- EVSE installations with respect to Amercians with Disabilities Act (ADA) requirements are not consistent

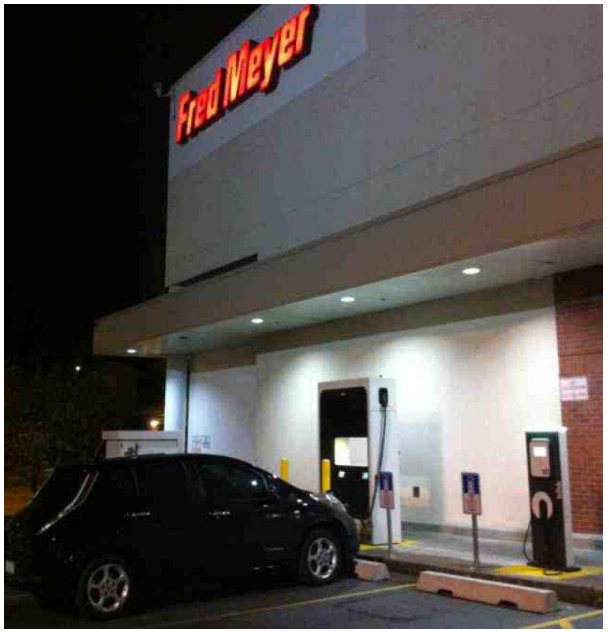
  "Charger is between 2 handicap spaces. To charge and not get ticketed you need to park behind the charger in any of 3 spaces closest to the elevator / entrance in non EV dedicated spots. Good Luck."

  – Comment from plugshare.com user

- Parking lot or garage may have
  - limited hours of operation
  - parking fees
  - restricted access

Charging Site Location Considerations

- Parking spaces in front of charging units may not always be accessible
  - Construction
  - Non-electric vehicle in parking spot (“you’ve been ICE’d”)
  - Electric vehicles in parking spots but not charging



Fred Meyer in Seattle, WA

Photos from plugshare.com

Charging Site Location Considerations

- Charging unit maintenance and reliability is a big factor

  "Both sides [of the DC fast charger] and level 2 not working. Had no electrics left. AAA couldn't send out the EV rescue truck because according to them they didn't have a tech trained to use it on hand. I ended up towing my car home. Not a good night."

  – Comment from plugshare.com user